ANÆSTHETICS

LEWIS'S PRACTICAL SERIES

DUDLEY W. BUXTON

ANÆSTHETICS

THEIR

USES AND ADMINISTRATION

LEWIS'S PRACTICAL SERIES.

CLINICAL BACTERIOLOGY AND HÆMATOLOGY FOR PRACTITIONERS. By W. D'ESTE EMERY, M.D., B.Sc. Lond., Clinical Pathologist to King's College Hospital, London, etc. 7s. 6d. *net.* [*Just published.*

DISEASES OF THE NERVOUS SYSTEM. A Handbook for Students and Practitioners. By C. E. BEEVOR, M.D. Lond., F.R.C.P., Physician to the National Hospital for the Paralysed and Epileptic. 10s. 6d.

THE TREATMENT OF PULMONARY CONSUMPTION. By VINCENT D. HARRIS, M.D. Lond., F.R.C.P., and E. CLIFFORD BEALE, M.A., M.B. Cantab., F.R.C.P., Physician to the City of London Hospital for Diseases of the Chest, etc. 10s. 6d.

THE SURGICAL DISEASES OF CHILDREN AND THEIR TREATMENT BY MODERN METHODS. By D'ARCY POWER, F.R.C.S., Surgeon to St. Bartholomew's Hospital, etc. 10s. 6d.

DISEASES OF THE NOSE AND THROAT. By F. de HAVILLAND HALL, M.D., F.R.C.P. Lond., Physician to the Westminster Hospital, and HERBERT TILLEY, M.D., B.S. Lond., F.R.C.S. Eng., Surgeon to the Hospital for Diseases of the Throat, Golden Square. Second Edition, 10s. 6d.

PUBLIC REALTH LABORATORY WORK. By H. R. KENWOOD, M.B., D.P.H., F.C.S., Professor of Hygiene and Public Health, University College, etc. Third Edition, 10s. 6d.

MEDICAL MICROSCOPY. By FRANK J. WETHERED, M.D., M.R.C.P., Medical Registrar to the Middlesex Hospital. 9s.

MEDICAL ELECTRICITY. By H. LEWIS JONES, M.A., M.D., F.R.C.P., Medical Officer, Electrical Department, St. Bartholomew's Hospital. Fifth Edition, demy 8vo, 12s. 6d. *net.* [*Just published.*

HYGIENE AND PUBLIC HEALTH. By LOUIS PARKES, M.D., D.P.H. Lond. Univ., Lecturer on Public Health at St. George's Hospital, and H. R. KENWWOD. M.B., D.P.H., F.C.S., Professor of Hygiene and Public Health at University College, London. Second Edition, 12s.

MANUAL OF OPHTHALMIC PRACTICE. By C. HIGGENS, F.R.C.S., Lecturer on Ophthalmology at Guy's Hospital Medical School, etc. Second Edition, 7s. 6d.

A PRACTICAL TEXTBOOK OF THE DISEASES OF WOMEN. By ARTHUR H. N. LEWERS, M.D. Lond., F.R.C.P. Lond., Senior Obstetric Physician to the London Hospital. Sixth Edition. 10s. 6d.

ANÆSTHETICS: their Uses and Administration. By DUDLEY W. BUXTON, M.D., B.S., M.R.C.P., Administrator of Anæsthetics at University College Hospital, etc. Fourth Edition. 7s. 6d. [*Just published.*

ON FEVERS: their History, Etiology, Diagnosis, Prog-NOSIS, AND TREATMENT. By A. COLLIE, M.D. 8s. 6d.

HANDBOOK OF DISEASES OF THE EAR. By URBAN PRITCHARD, M.D. Edin., F.R.C.S., Professor of Aural Surgery at King's College, London, etc. Fourth Edition. [*In preparation.*

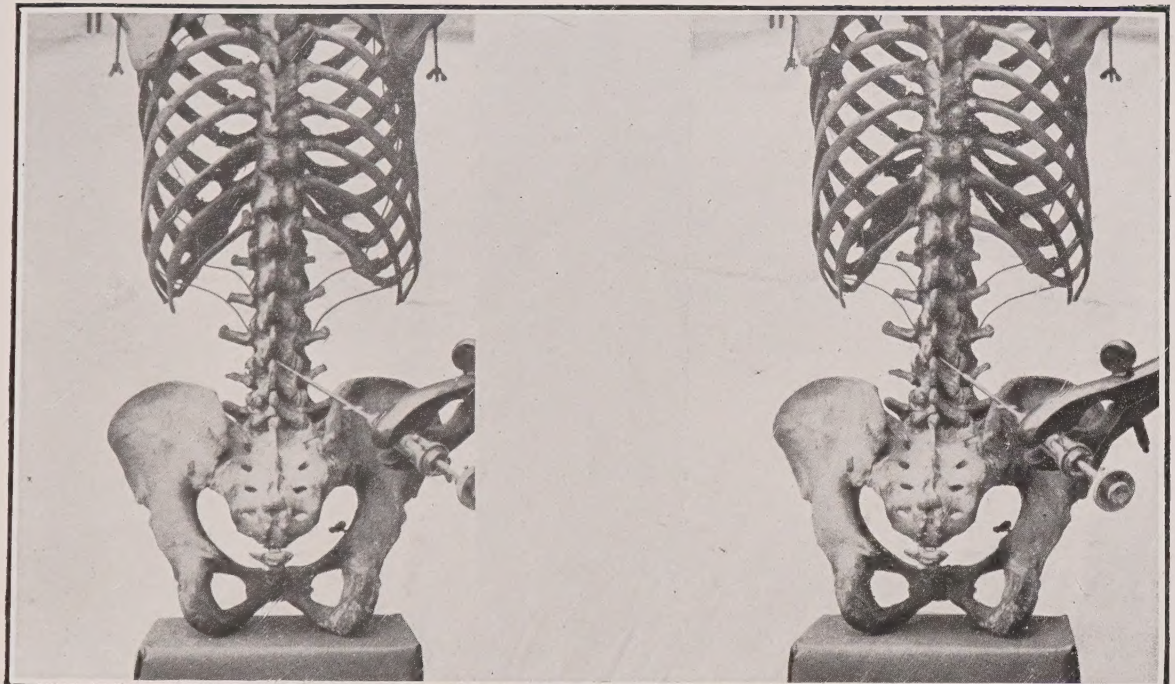
A PRACTICAL TREATISE ON DISEASES OF THE KID-NEYS AND URINARY DERANGEMENTS. By C. H. RALFE, M.A., M.D. Cantab. F.R.C.P., Physician to the London Hospital. 10s. 6d.

DENTAL SURGERY FOR MEDICAL PRACTITIONERS AND STUDENTS OF MEDICINE. By ASHLEY W. BARRETT, M.B. Lond., M.R.C.S., L.D.S., Consulting Dental Surgeon to the London Hospital. Fourth Edition. 3s. 6d.

BODILY DEFORMITIES AND THEIR TREATMENT. By H. A. REEVES, F.R.C.S. Ed., Senior Assistant Surgeon and Teacher of Practical Surgery at the London Hospital. 8s. 6d.

LONDON: H. K. LEWIS, 136, GOWER STREET, W.C.

[illegible]



Method of spinal injection. If these figures are looked at through a stereoscope, the exact position of the needle is well seen. [Mr. Mackenzie Davidson has kindly taken these photographs.]

ANÆSTHETICS

THEIR

USES AND ADMINISTRATION

BY

DUDLEY WILMOT BUXTON, M.D., B.S.

MEMBER OF THE ROYAL COLLEGE OF PHYSICIANS; SOMETIME PRESIDENT OF THE SOCIETY OF ANÆSTHETISTS; MEMBER OF UNIVERSITY COLLEGE; ADMINISTRATOR OF ANÆSTHETICS AND LECTURER IN UNIVERSITY COLLEGE HOSPITAL; CONSULTING ANÆSTHETIST TO THE NATIONAL HOSPITAL FOR PARALYSIS AND EPILEPSY, QUEEN'S SQUARE, AND SENIOR ANÆSTHETIST TO THE DENTAL HOSPITAL OF LONDON

FOURTH EDITION

LONDON
H. K. LEWIS, 136, GOWER STREET, W.C.
1907

PREFACE TO THE FOURTH EDITION.

The present edition includes fresh articles dealing with dosimetry in chloroform, the use of ethyl chloride as a general anæsthetic, and the production of anæsthesia by spinal injection. To make room for these it has been necessary to omit some paragraphs and descriptions. The writer has attempted to place before his readers such facts and theories concerning anæsthetics as he deemed to be essential; he makes no claim to have included either the views of all competent authorities, or any account of the apparatus which in his judgment are not necessary for the beginner. The manual is intended as a handbook for students and practitioners, and as such contains only what the writer has personally tested, and upon which he has been enabled to form an opinion. The chief additions are the introduction of a full description of Mr. Vernon Harcourt's chloroform regulator; some mention of Dr. Dubois' and Dr. Levy's dosimetric chloroform apparatus; an account of ethyl chloride and its mixtures; and a *resumé* of recent work dealing with the local analgesia and spinal anæsthesia. The whole of the book has been revised and largely re-written, so as to include some account of recent scientific research upon anæsthetics.

Much help has been given by various colleagues and friends, and to these, and especially to Dr. Inglis Clark,

Dr. Beresford Kingsford, and to Mr. Mackenzie Davidson, the last of whom has kindly taken the stereoscopic photographs from which the frontispiece has been prepared, the writer offers his thanks. Dr. Hewitt has again lent blocks, and various others have assisted in like manner; to them and to Messrs. Duncan & Flockhart, who have assisted in many ways, a debt of gratitude is acknowledged. The extreme difficulty of epitomising so large a subject as is the study of anæsthetics must be advanced for many omissions and much curtailment. The writer has felt, however, it is best to supply a system which, if incomplete, represents what is accepted by most competent observers, rather than to attempt to harmonise conflicting views, and so overload the pages of a practical manual with details unessential and of ephemeral importance.

82, Mortimer Street, W.

CONTENTS.

CHAPTER VI. *(continued).*

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

ANÆSTHETICS.

INTRODUCTION.

The experience gained in teaching the principles underlying the safe use of anæsthetics in surgical practice has led the author to believe that the following suggestions how to use this manual may prove of service. Many have little time to wade through details, while others have so slight a special knowledge to start upon that an attempt to read a practical book from commencement to end makes confusion worse confounded.

In primis, even at the risk of offering superfluous advice, it is urged upon those who hope to acquire proficiency in the use of anæsthetics that unless they realise to the full the responsibility which must be assumed by the anæsthetist, they will never attain to even the foundation of their art. The timid and the reckless are equally dangerous, the one because he has no faith in his knowledge, the other because he has never realised that his skill and knowledge alone stand between his patient and peril, possibly death.

Whatever apparatus is employed, it should be personally examined before use, and the anæsthetic employed should be smelt before being placed in or upon the inhaler. The armamentarium of the anæsthetist should consist of the inhaler selected, an adequate quantity of the anæsthetic which has been chosen as most suitable for the

patient, and if the particulars of the case are not known, an alternative anæsthetic; a gag, tongue forceps, sponges with holders, a mouth opener, tracheotomy instruments and intubation tubes, as well as a solution of strychnine with a hypodermic syringe. In cases in which special dangers are apprehended additional aids are required, such as a cylinder of oxygen, a bellows fitted with india-rubber tubing, for pulmonary perflation. All instruments, rubber bags and face-pieces should be carefully and thoroughly cleansed before and immediately after use. In cold weather the rubber of tubes and face-pieces should be rendered pliant by warming in hot water.

Plan of study.—It is suggested that the student commencing the subject should read the chapters in the following order, paying particular attention to the physiological action of the anæsthetic substances therein described.

In Chapter II., p. 23, is a consideration of the general preparation of a patient and this should be mastered before the succeeding pages are read, dealing with the choice of the anæsthetic. This subject is further expanded on pages 305, 322, and 330, when the anæsthetics in use in the surgery of the various regions, thorax, abdomen, in parturition, &c., are considered.

It is desirable that the methods of giving nitrous oxide should be studied, both because they are essential in themselves, and because in many cases when ether is used, it is advantageously preceded by the employment of nitrous oxide (p. 55). In short cases nitrous oxide can be administered by itself, but a considerable experience is required with this anæsthetic to enable the administrator to manage it properly. Only after many attempts can he obtain sufficient mastery of methods to acquire the power of producing a prolonged working anæsthesia.

The physiological action of nitrous oxide (pp. 57 to 66) should be carefully perused, then the description of the simplest apparatus (pp. 68 to 79) may follow. The administration (pp. 80 to 84) with "after-effects" and dangers (pp. 91 to 101) should be read before the sections dealing with the more complex methods of giving mixtures of nitrous oxide coincidentally with air or oxygen. The prolongation of nitrous oxide anæsthesia may be omitted at first, but the pages dealing with the methods proposed to effect it, must be reverted to at a later stage (pp. 87 to 113).

The student is recommended to peruse from p. 116 to p. 147 and master the principles of the administration of ether. It is better to gain familiarity with the use of one method before the attention is given to elaborations which, although most necessary in special cases, are wisely omitted in a first reading. The method recommended is nitrous oxide gas preceding ether by the plan suggested by Clover (pp. 112 and 147). The alternative plan of giving ethyl chloride followed by ether is one now commonly adopted and will be found described on p. 155. For ether inhaled alone the method described at pp. 128 to 136 should be adopted. Pages 143 to 147 must be read concurrently with the above descriptions. Pages 162 to 177 should be carefully studied, since they deal with the complications, &c., of ether inhalation. Ether given in combination with other narcotics is dealt with on pp. 147, 158, 269, 289, 296, and 302, and these sections may be omitted for a subsequent reading, as well as pp. 158 to 161, which refer to rectal etherisation.

Passing to chloroform, the reader is advised to devote his attention at first to pp. 186 to 201. Of inhalers, that of Mr. Vernon Harcourt (p. 203) is certainly the best, but the modern form of Junker is also recommended (p. 214). The paragraphs dealing with methods on p. 221 should be next

read, although the "open method" is not to be taken as of equal value with the exact dosage plan rendered possible by the use of a regulating apparatus such as those of Harcourt or Junker. The remainder of Chapter V. may be read in the order in which it is written.

The complications and dangers liable to arise while a patient is inhaling nitrous oxide, ether or chloroform, are dealt with in the chapters which refer to the inhalation of these anæsthetics, but the subject is more fully elaborated and brought into a common focus on pp. 330 to 355. Although this has involved some repetition, such is thought to be justified by the manifest advantage of having "accidents" grouped together in one chapter devoted to their consideration. Chapter VIII. may next be read, as it will enable the reader, who should have mastered the general principles involved in giving nitrous oxide, ether, and chloroform, to apply his knowledge to the special cases therein detailed. Explanations are given on pp. 305 to 321, which it is hoped will enable the reader to understand special precautions and manipulations which are required during the performance of many operations which from their nature may involve the anæsthetist in difficulties. Chapter IX. deals with the special application of anæsthetics to obstetric surgery.

Since no one can safely embark upon so serious a responsibility as that of administering anæsthetics until he has studied his position from a medico-legal standpoint, the reader is advised to peruse at this point the final chapter of the manual, pp. 380 *et seq.* The remaining sections of the book should be read for special information concerning the various anæsthetics, mixtures, successions and local analgesics with which they deal.

CHAPTER I.

HISTORICAL.

Means for producing surgical anæsthesia were practically unknown until Wells introduced nitrous oxide, Morton employed ether, and Simpson choloroform. With the first employment of these three agents commences the history of artificial anæsthesia, although from very early times attempts were made to obtain insensibility during surgical operations.

Nepenthes or sedative draughts to relieve severe pain are mentioned in the Odyssey—Helen seeking to "drown all sense of woe" and to assuage the sufferings of Menelaus by such means. In Egypt, cannabis indica, the modern hashish, and other drugs, were similarly used. The "wine of the condemned" spoken of by the seer Amos was held by Simpson to have been derived from cannabis indica. Both among the Jews and the Chinese, narcotics were given to criminals to alleviate the agonies of their death struggles. The Assyrians and Chinese seem to have employed various drugs with a view to relieve the anguish of wounds and such rough surgery as was practised among them. Dr. Dudgeon of Pekin, however, gives little credence to the somewhat exaggerated narratives which have appeared concerning the extent to which anæsthesia was practised among the Chinese.

Opium, cannabis indica, carbonic dioxide, and deadly nightshade, were advocated in various forms to achieve this object. Pliny and Dioscorides describe several

methods in vogue among the Romans and other nations for benumbing parts subjected to incision and cauterisation. Memphis marble as a local anæsthetic, for example, was finely powdered and applied to the part and on the addition of vinegar a gas was given off (carbonic dioxide) which rendered the part slightly anæsthetic. Various members of the Euphorbiaceæ, Mandragora, and other Solanaceous plants, were also employed in infusions, which on being drunk induced some narcotism. Sir Benjamin Ward Richardson prepared a draught from some Atropa Mandragora, following the directions given by Dioscorides, and stated that he found the potion a satisfactory anæsthetic. Attempts at anæsthesia by inhalation were very early practised. The Scythians burned cannabis indica and inhaled its fumes to alleviate pain. Snow has, however, pointed out that most of the drugs, the fumes of which were supposed to induce anæsthetic sleep, were really non-volatile, so whatever effect was produced must have arisen from the evaporation of the spirit used in preparing the solutions.

In more modern times little advance was made until the last century. Most surgeons were contented to put their patients deeply under opium. Many "Drowsy Syrups" were employed in the middle ages. The celebrated "Spongia Somnifera" of Theodoricus of Lucca (1298) contained opium, hyoscyamus, cannabis indica, mulberry, mandragora, conium, wood ivy, lettuce, and water hemlock. Boccaccio, Shakespeare, and other writers frequently refer to potions given to dull the senses while amputations, etc., were performed. Such a draught was, it is said, given to Augustus, King of Poland, by his favourite Surgeon, Weiss (1782), without the monarch's knowledge, so that the royal foot could be removed without pain.

In 1661, Greatrakes, a professional "stroker," practised anæsthetic mesmerism. He exploited his art before Charles II. In a MS. dated twenty years later, one Denis Papin, wrote that he possessed the means whereby he could abrogate all painful sensations during a surgical operation, but what his method was, was left unexplained.

In the 16th and 17th centuries Valverdi and others operated upon patients stupefied by compression of the carotid arteries, so depriving the brain of blood. In this practice they seem to have been anticipated by the Assyrians, who are reported to have compressed the vessels of the neck to render painless the operation of circumcision. James Moore, an English surgeon, in 1784 revived a suggestion, originally made by Ambroise Paré, that compression of the nerve-trunks should be practised before cutting the areas supplied by them, and John Hunter actually took advantage of the plan, and amputated a leg in St. George's Hospital after firmly compressing the crural and sciatic nerves. Wardrop (1832) proposed to operate upon patients rendered unconscious by bleeding them until syncope resulted. Richerand and other surgeons adopted the plan of rendering their patients intoxicated before applying the knife.

A departure in an entirely new direction was made by Mesmer, and his followers, who averred that patients thrown into the "magnetic state" (*i.e.* hypnotised) could be surgically treated without any pain or inconvenience. Long before Mesmer lived, a belief had been current that the natural magnet possessed powers which were both curative of disease and capable of establishing anæsthesia. Thus Cardan (1584) recounts how the magnet could be employed to abrogate pain. The germs of the facts now known and accepted under the terms animal magnetism and hypnotism bore a fruitful harvest of windy words,

Paracelsus, Glocenius, Burgrave, and others, contributing largely thereunto. By Anthony Mesmer (born 1734), however, the matter was advanced from theory to practice, and although we may carp at Mesmer as a charlatan and a quack, we must accord to him a meed of gratitude for establishing upon a practical basis a theory which before his age was lost in useless verbiage. In 1776, Mesmer published his work, "The Influence of the Planets in the Cure of Disease," which maintained that the celestial orbs exercised, by means of "animal magnetism"—an all-pervading fluid, an influence benign or malign on human beings. Fourteen years later, in conjunction with a Jesuit called Father Hell, Mesmer undertook the cure of disease at first by means of the Magnet and steel "tractors," but finally by means of manual passes. The plaudits which at first greeted Mesmer in Vienna were ere long changed for the most hostile treatment, the learned bodies of his own and other countries treating his writings with contempt and himself with contumely. Leaving Vienna, Mesmer exploited Paris, and here he founded the widely famed hospital whereat he treated a great number of patients. In 1785 a Royal Commission was appointed to enquire into Mesmer's pretensions, but this and subsequent Commissions unfortunately confused the issues in question, and while they decided that Mesmer and his immediate adherents were unworthy of credence, they failed to recognise the substratum of truth underlying their teaching and practice. After Mesmer's downfall the subject was kept before the world by the practice of the Marquis de Puységur and the somnambulists. In 1829, Cloquet amputated a breast, the patient being rendered insensible through having been thrown into the hypnotic state. Elliotson, a firm believer in the practical uses of animal magnetism in surgery, employed it on several

occasions with success. Braid, of Manchester, in 1841 made considerable trial of what he called the "neur-hypnotic trance" as a means of producing surgical anæsthesia. Similar experiments were carried out in India by Dr. Esdaile, who performed no less than three hundred operations upon patients in the hypnotic state. Ephemeral attempts have from time to time been made to revive the practice of hypnotism for the induction of anæsthesia with but partial success. It has been found that while only a certain number of persons are capable of being completely hypnotised, even these, as a rule, require many séances under the hands of the magnetiser before the requisite degree of insensibility to pain is attained. Again, the mental state thus called into existence is in a large number of cases highly prejudicial to physical and moral well-being, and hence the consensus of opinion at present is rather adverse to the employment of hypnotism in anæsthetic practice, save in very exceptional circumstances and under carefully guarded conditions.*

In the 18th century the history of discoveries concerning anæsthetic methods becomes merged in that of the progress of chemical research. Hales, Lavoisier, Priestley, and Cavendish, opened up rich stores of knowledge by their discoveries in connection with the gases. Oxygen, nitrogen, nitric oxide, were prepared and closely studied, and, in 1772, Priestley added nitrous oxide gas to the list. Pneumatic chemistry, till then unknown, became the absorbing theme among chemists, while physicians sought to bring the recent discoveries to account by pressing these gases into the service of medicine. Dr. Beddoes in

* Prof. Grainger Stewart (*Lancet*, Oct. 21, 1893, p. 1018) said: "In every case hypnotic treatment involved hazard to the nervous system, and that those who were most susceptible to its treatment were the most apt to suffer, and that though it might free the patient from one set of symptoms it was apt to make him the victim of many others."

1798, assisted with finances by Wedgwood, the renowned potter, inaugurated his Pneumatic Institution at Clifton, where he proposed to treat phthisis and many other diseases by inhalations of various gases.

The Pneumatic Institute is interesting mainly because its first superintendent was Humphry Davy, who prosecuted therein his researches concerning nitrous oxide and other gases. In 1799 Davy discovered that "as nitrous oxide, in its extensive operation, appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Davy substantiated his statements by most careful experiments upon the lower animals, extending Hales' research, which had been confined to mice, and demonstrating many facts, the practical uses of which were not appreciated for more than forty years later. But his philosophic mind did not content itself with limiting his experiments here; he actually inhaled the gas and found its influence to assuage the pains of toothache, and in his "Researches" are recorded his own sensations and the behaviour of others after inhaling nitrous oxide gas. Early in the nineteenth century Dr. Hickman, a London surgeon, suggested that he had discovered a painless mode of operating. This was possibly achieved by the patients inhaling carbonic acid gas, but his statement met with scant favour.

The discovery made by Davy was not brought within the field of practical application until Horace Wells, a dentist of Hartford, Connecticut, conceived the idea of using nitrous oxide gas as an anæsthetic for tooth extraction. Wells went to a popular lecture delivered before the inhabitants of Hartford by a Mr. Colton, an itinerant lecturer on chemistry. During the performance one of the audience inhaled an impure sample of nitrous oxide

gas and became very excited. In the course of his gyrations this individual wounded his leg but felt no pain, a circumstance of which Wells was not slow to take notice. The following day, Dec. 11th, 1844, Mr. Colton at the request of Wells administered gas to him, and during the ensuing unconsciousness, a Mr. Riggs, another dentist, extracted a molar from Wells' jaw. Wells, as he regained consciousness, cried out, "A new era in tooth pulling. It did not hurt me as much as a prick of a pin. It is the greatest discovery ever made."

After successfully employing gas as an anæsthetic among his own patients, Wells essayed a public demonstration in the operating theatre of the Boston General Hospital. The person experimented upon was not rendered completely unconscious, and gave unequivocal signs of having felt pain. This failure not only ruined Wells, who became insane, and finally died in prison by his own hand, having inhaled ether to ensure euthanasia in 1848, but it also discredited nitrous oxide as an anæsthetic.

With the death of Wells and the introduction of ether as an anæsthetic, the vogue of nitrous oxide, for the time, ceased; but Colton, remembering his experience at Hartford, revived its use in 1863. Lee Rymer in England and Hermann in Germany undertook (1864-6) some experiments with nitrous oxide, and the important investigation of Krishaber followed in 1867.

Subsequently Colton induced various dentists to experiment, and in 1867 he was able to give a record of 20,000 successful cases. In 1868 * the anæsthetic properties of nitrous oxide gas were successfully demonstrated at the Dental Hospital of London, and a committee of the lead-

* Colton, while in Paris, met with the well-known dentist, the late Dr. Evans, mainly owing to whose energy and munificence Colton's apparatus was conveyed to London, where the merits of nitrous oxide gas were brought before the English faculty.

ing English dentists was formed. The two reports published by these gentlemen, and read before the Odontological Society of Great Britain, spoke in warmest praise of the agent, and practically established its claims as a safe and efficient anæsthetic for short operations, in spite of considerable opposition on the part of certain members of the medical profession, who denounced nitrous oxide as unsatisfactory and dangerous.

The enthusiasm and ingenuity of Mr. Clover played no small part in obtaining the adoption of nitrous oxide for general use. It was shortly afterwards that Mr. Clover suggested what may be called one of the most important improvements in practical anæsthetics, the employment of nitrous oxide as a preliminary to the inhalation of ether.

The discovery of ether is attributed to an Arabian chemist, Djaber Yeber, and its method of manufacture to Dr. Michael Morris, who also suggested that it could be used with advantage in medicine by inhalation.*

The general properties of ether, and its value as an inhalation, were well known before its use was suggested for the purpose of obtaining anæsthesia. In Pereira's work on "Materia Medica and Therapeutics," published in 1839, it is expressly stated that when ether is inhaled to produce a sedative effect in spasmodic diseases, there is a danger that the patient will become stupefied unless the ether vapour is sufficiently diluted. Its introduction as an anæsthetic, however, is commonly held to be due to American enterprise. It was fairly well known, and its properties recognised, as early as 1785, when Dr. Pearson, of Birmingham, employed it as an inhalation for asthma, and early in the last century it was used in the treat-

* For much valuable information about the discovery of Ether and Chloroform, the reader is referred to Mr. George Foy's work "Anæsthetics, Ancient and Modern," pages 23, 32 and 54.

ment of phthisis. In 1818 a paragraph appeared in the *Journal of Science and Arts*, which although unsigned is generally supposed to have emanated from the pen of Faraday; it runs: "When the vapour of ether is mixed with common air and inhaled, it produces effects very similar to those occasioned by nitrous oxide." Then follows an account of an experience with ether; a gentleman who inhaled, became "lethargic," and so remained for thirty hours. Facts about the narcotic properties of ether were rapidly brought to light, and the writings of Orfila, Brodie, Giacomini, and Christison, all give more or less accurate accounts of the stupefying effects of ether. About the year 1840 it was a common trick at lectures and among medical students to inhale ether-vapour in order to induce exhilaration. A number of lads were indulging in this pastime in the outskirts of Anderson, South Carolina, and to stimulate further their mirth they seized upon a negro boy and forced him to inhale ether, pressing the vapour upon him until he became deeply narcotised and apparently dead. In an hour, however, to the delight of his tormentors, the negro resumed consciousness. This scene impressed itself so deeply upon one of the lads, named Wilhite, that when three years subsequently he became the pupil of a Dr. Crawford Long, of Jefferson, Jackson County, U.S.A., he narrated to him, it is said, his experiences of ether.

Dr. Long published in 1849 a statement that he had in 1842 administered ether to a patient, and while the patient was thus narcotised, a small tumour was painlessly removed. The same surgeon employed ether as an anæsthetic on several subsequent occasions with a like success. Dr. Long, however, only employed ether a few times, and made no attempt, until after Morton's public demonstration of the efficiency of ether as a general anæs-

thetic, to extend his practice of ether giving for the benefit of mankind. Dr. Long * appears to have acted in all candour, he had adopted a great invention, but failing to recognise its immense possibilities he left for others a discovery which he had made and underrated. Other medical men also about this time employed ether for surgical anæsthesia. A student named William Clarke, in 1842, administered ether at Rochester, New York, to a patient for tooth extraction, and Dr. Marcy, also an American, operated upon an etherised patient in 1844.

However, the employment of ether as a general anæsthetic is more usually associated with the name of Morton, a dentist of Boston. William T. G. Morton was a pupil of Horace Wells, and from his master he gathered his first impressions concerning artificial anæsthesia. It would subserve no useful purpose to open up the miserable quarrels and recriminations which have been connected with Morton and his share in the introduction of ether as an anæsthetic. It will be best, therefore, merely to state the facts as far as possible without bias.

Wells made Morton his partner in a dental practice he proposed to start in Boston. The removal from Hartford to Boston was consequent upon a discovery Horace Wells had made of some solder with which he hoped to achieve great things. To confirm his own estimate of the value of this solder he called in a Dr. Jackson, a scientific chemist, who expressed a favourable opinion. However, the partners soon fell out, and Wells returned to Hartford, leaving Morton in Boston. The latter asked Wells for

* The share Dr. Crawford Long had in the discovery of ether as an anæsthetic has given rise to much controversy, but the facts appear to have been as given in the text. In a recent paper by Dr. Luther B. Grandy, it is stated that Wilhite's experience did not suggest the use of ether to Dr. Long, as he had employed it before he became acquainted with young Wilhite.—"History of the Discovery of Modern Surgical Anæsthesia."

information as to the production of nitrous oxide, and was by him referred to Dr. Jackson. It was suggested by the chemist that trial should be made of sulphuric ether instead of laughing-gas, since it was more easily obtained. Acting upon the suggestion, Morton set to work with great assiduity to experiment, using chloric ether. He induced two students, Spear and Leavitt, to inhale ether, but the results were unsatisfactory. He next tried dogs, and, again at Jackson's instance, used rectified ether, inhaling it from a tube attached to a flask. This is the story of Morton's discovery, given in his own words: "I procured the ether from Burnett's, and, taking the tube and flask, shut myself up in my room, seated in the operating chair and inhaling. I found the ether so strong that it partially suffocated me, but produced a decided effect. I then saturated my handkerchief, and inhaled from that. I looked at my watch, and soon lost consciousness. As I recovered I felt a numbness in my limbs, with a sensation like nightmare, and would have given the world for some one to come and arouse me. I thought for a moment I should die in that state, and that the world would only pity or ridicule my folly. At length I felt a slight tingling of the blood in the end of my third finger, and made an effort to touch it with my thumb, but without success. At a second effort I touched it, but there seemed to be no sensation. I gradually raised my arm and pinched my thigh, but I could see that sensation was imperfect. I attempted to rise from my chair, but fell back. Gradually I regained power over my limbs and full consciousness. I immediately looked at my watch, and found that I had been insensible for between seven and eight minutes." A patient, Eben Frost, requiring to have a tooth out, and fearing the pain, requested Morton to mesmerise him, but Morton

promptly seized his chance, and persuaded him that he knew a far better means of preventing the pain. The experiment was made, and on September 30, 1846, ether was successfully given by Morton and a tooth painlessly removed. The "discovery" was reported to Warren, the well-known surgeon, and by his consent a patient was etherised in the clinical room of the Massachusetts General Hospital. The experiment was repeated, and each time proved a remarkable success. Warren, however, substituted chloric for sulphuric ether in subsequent operations and is said to have preferred it.*

The possibility of narcotism by inhaling vapours having become an accomplished fact, it became necessary to find words expressing the agents used and the state induced. Morton adopted the term "Letheon," but this word soon fell into desuetude after the suggestion by Oliver Wendell Holmes of the expressions Anæsthesia for the state, Anæsthetic agent for the drug employed. Simpson regretted that the word Nodynia had not been accepted rather than Anæsthesia.

In England, the first administration of ether took place in Gower Street, London, close to University College Hospital, when Mr. Robinson, a dentist, gave ether and removed some teeth. This took place on Saturday, December 19, 1846, at the house of Dr. Boott. On Monday, December 21, Liston amputated through the thigh in University College Hospital, the patient being placed under the influence of ether by Mr. Squire.

Dr. Snow, early in 1847, commenced the successful administration of ether in St. George's Hospital, but upon the introduction of chloroform he gave up ether for its more pleasant but possibly less safe rival.

* "Personal Recollections of the First Use of Anæsthetics," by J. V. Galloupe, M.D., *Boston Medical and Surgical Gazette*, January 7, 1897.

On January 19, 1847, Dr. (afterwards Sir James Young) Simpson administered ether to a woman in childbirth, and subsequently adopted it in his obstetric practice. Notwithstanding the favourable experiences of many, ether was not rendered popular for some years subsequently. The methods in vogue for its administration were far from satisfactory; many patients never got beyond the stage of exhilaration and wild excitement, and their struggles and bacchanalian shouts were pronounced highly embarrassing to the operator. These considerations led Liston and other eminent surgeons to regard ether with suspicion, and made them diffident in invoking its aid. However, up to November, 1847, the time of Simpson's world-famed pamphlet, "Notice of a New Anæsthetic Agent as a Substitute for Sulphuric Ether in Surgery and Midwifery," ether was slowly but surely winning its way as a safe and trusty anæsthetic. With the introduction of chloroform, came the *coup de grâce* to the predominance of ether. With an almost incredible rapidity chloroform supplanted her elder sister, not only in Great Britain but almost throughout the world; in America, however, many surgeons still clung to ether. The story of the introduction of chloroform into Great Britain is soon told. Sir James Y. Simpson,* not wholly satisfied with ether in obstetric practice, asked Mr. Waldie, the Master of the Apothecaries' Hall of Liverpool, if he, as a practical pharmacist, knew a substance likely to be of service in producing anæsthesia. Mr. Waldie being acquainted with the composition of "chloric ether" suggested that its "active principle," chloroform, should be prepared from it and

* For an interesting account of Simpson's work in connection with the introduction of chloroform, see "Sir James Y. Simpson" in Famous Scots Series. Also see Simpson's "Collected Works," vol. ii., "Anæsthesia."

used. He never carried out his promise to prepare some for Simpson to try, and so the desired substance was obtained in Edinburgh, and Simpson experimenting on himself, George Keith, and Matthews Duncan, on November 4, found its use perfectly satisfactory. He at once tried chloroform in his obstetric practice and met with success.

The favourable opinion he had formed he expressed in his paper read before the Medico-Chirurgical Society of Edinburgh, November 10, 1847. On November 15, 1847, the first surgical operation was performed at Edinburgh, upon a patient who was under the influence of chloroform. It is curious to note how narrowly several persons escaped discovering the value of chloroform as an anæsthetic. Thus, chloric ether, a twelve per cent. solution of chloroform (by volume) in spirits of wine, was employed by Dr. Bigelow, of Boston, but with only partial success. Jacob Bell, of London, however, actually produced insensibility by its use an an inhalation, and Sir William Lawrence, the surgeon, employed it alike in private and hospital practice. Chloric ether was also used at St. Bartholomew's and the Middlesex Hospitals, but the great uncertainty of its action and the expense of procuring large supplies effectually prevented it from gaining ground as an anæsthetic.

Mr. George Foy* has pointed out that in Silliman's *American Journal of Science and Art*, January, 1832, Professor Ives of Newhaven, reports a case, in which chloroform was employed as an anæsthetic. Guthrie, an American chemist, was induced by a statement in Silliman's "Chemistry" that an alcoholic solution of chloric ether was a valuable stimulant, to attempt a

* *Op. cit.* p. 37.

cheap way of producing it.* Guthrie gives directions for the distillation of chloride of lime and "well flavoured alcohol" of sp. gr. 0·844. Soubeiran's account of his discovery of chloroform, made apparently without any knowledge of Guthrie's work, appeared six months after Guthrie's MS. was in the printer's hands. About the same time another independent observer, Liebig, published an account of chloroform, but he failed to recognise in his analysis the presence of hydrogen, and therefore regarded the material as a chloride of carbon. It was not until 1834 that Dumas adopting more exact methods revealed its true chemical composition.

Chloroform was experimentally studied by Flourens in 1847, but no practical uses were made of his work. For some while chloroform was believed to be a "safe anæsthetic," an impression to which the language of Simpson's pamphlet rather lent itself, although certainly no explicit statement to that effect can be found. Unhappily this belief received a rude shock when on January 28, 1848, a death from chloroform was reported at a place near Newcastle-on-Tyne. This untoward occurrence was soon followed by other deaths, and men's minds became anxious. At this pass Snow, with that earnestness and acumen which characterised all he undertook, commenced his researches into the subject. In 1848, he published his "Experimental papers on narcotic vapours."

Although Snow had improved upon the methods in vogue for exhibition of ether by the invention of his inhaler, he did not vaunt its merits above other narcotics, and in 1847 he perfected his chloroform inhaler, being actuated by the belief that that anæsthetic kills through being used in too concentrated a vapour. Snow's experi-

* See "The True History of the Discovery of Chloroform," by David Waldie, Edinburgh, Oliver and Boyd, 1870.

ence, like that of most others, made him regard chloroform as dangerous, and so in 1856 he was tempted to investigate amylene, of which substance he entertained a high opinion.

A committee appointed by the Royal Medical Chirurgical Society of Great Britain to investigate the subject of anæsthesia tendered their report in 1864, and this report strongly insisted both upon the danger of chloroform and the inconvenience of ether as then administered. Many suggestions, such as the use of the A.C.E. mixture, were embodied in the report, some of which Clover, who had then achieved a high reputation as an anæsthetist, was not slow in carrying to a practical issue. In 1862 Clover had constructed and published an account of his chloroform apparatus by which he regulated the percentage of vapour administered.

Pollock and Warrington Haward in this country were keenly alive to the dangers of chloroform, and they lost no opportunity of urging the use of ether, an advocacy for which we must always feel grateful. As time went on Clover was less and less inclined to use chloroform. For minor operations he found nitrous oxide gas given by his apparatus to answer best, and he was led to seek some means for prolonging anæsthesia so obtained. This he achieved by the employment of ether in succession to nitrous oxide, for which he soon devised an admirable apparatus, described in the *British Medical Journal* in 1876. It may be remarked that this inhaler is at the present time less known than its merits deserve. Subsequently his portable regulating ether inhaler was introduced, and it was mainly by the compactness and efficiency of this instrument that the practical question "How to give ether rapidly and safely?" became answered. In latter years Clover adopted the use of

bichloride of ethidene, first introduced under the name of "monochlorurretted chloride of ethyle" by Snow in 1851, but Clover's record of 1877 with one death did not lead to the general adoption of this new anæsthetic. In 1879 the British Medical Association undertook to reinvestigate the question of the relative safety of the various anæsthetics, and appointed a committee to carry out experiments. The conclusions to which this, the "Glasgow Committee," arrived were in favour of ether, as they found chloroform lowered the blood pressure and depressed the action of the heart. In 1889 the Nizam of Hyderabad, at the suggestion of Surgeon Lieut.-Colonel Lawrie, granted a considerable sum of money to re-open the question, and the first Hyderabad Commission, working upon small mammals in India, came to conclusions more favourable to chloroform. As these investigations were not held convincing by English experts, a second Hyderabad Commission, in which Sir Thomas (then Dr.) Lauder Brunton assisted, went over the ground again, and corroborated the results before obtained by the first Hyderabad Commission.

The Lancet, with public-spirited zeal, undertook and carried out an exhaustive Report dealing with the clinical evidence on the uses of chloroform and other anæsthetics, and published it in 1893. The results of clinical observations therein embodied did not bear out all the statements of the Hyderabad Commission. The British Medical Association as a result of a discussion held at the Annual General Meeting at Bournemouth in 1891, when the present writer read a paper on "The Clinical Aspects of Anæsthesia,"* appointed a Committee to study the question. The report of this Committee appeared in 1900, and contained an analysis of 25,920 cases in which anæsthetics had been given and records kept.

* *British Medical Journal*, vol. ii., p. 1090, 1891.

The important researches of Gaskell, Hare, Leonard Hill, McWilliam, Shore, Waller and Wood, have all appeared within the last few years and have kept alive the controversy which has existed since the initial use of chloroform. These experimental results are considered more at length in the chapter dealing with chloroform.

It is not within the scope of this book to notice in detail the more recent work which has been sufficiently constructive to deserve a mention in the history of the subject. It may, however, be noted that Dr. Embly, of Melbourne, by an important research has increased our knowledge of the obscure subject of vagus inhibition during narcosis. This and other researches appear in the *Transactions of the Society of Anæsthetists*, a society which has done much to promote an intelligent study of anæsthetics. The British Medical Association (1901) has again testified its public spirited interest by appointing a further Committee* to investigate methods of quantitatively determining the presence of chloroform in the air and in the human body. The work of this Committee has already been fruitful in much valuable research.

* The Committee as first appointed consisted of Dr. Barr, Dr. Dudley Buxton (Secretary), Mr. Vernon Harcourt, F.R.S., Sir Victor Horsley, F.R.S., Professor Sherrington, F.R.S., and Dr. A. D. Waller, F.R.S.

CHAPTER II.

PREPARATION OF A PATIENT AND CHOICE OF AN ANÆSTHETIC.

Best time for taking an anæsthetic.—Although the anæsthetist seldom has the choice of time given to him, the selection of a suitable hour for the operation is not a matter of indifference in administering an anæsthetic. The effect of anæsthetisation upon the robust may be considered trifling and transient, yet when the person to be anæsthetised is an invalid, and either weakly or neurasthenic, the inhalation may have both a dangerous and prolonged influence. Individuals are more liable to after-effects of an unpleasant character when their bodily condition is one of nervous exhaustion and lowered vitality. It is inadvisable, therefore, unless over-riding circumstances exist, to give an anæsthetic after an unduly prolonged fast. Similarly, it is unwise to select an advanced hour of the evening when the body will be spent after a day of activity or suffering.

Dietary.—Further, an anæsthetic should not be given within three hours of a meal of food not easily digested, as a full stomach impedes the production of narcosis and excites vomiting. This last occurring during partial narcosis may occasion fatal accidents through solids being drawn into the air passages. It is well to select the periods of greatest vital activity, and this is found in most persons in the morning (8 a.m.) or early afternoon (2 p.m.). Speaking generally it is well to arrange for a very light

meal of soft and easily digested matters to be taken three, or better four, hours at least before the surgeon arrives. But it is best when possible, unless the patient be in a very feeble state of health, to adopt Clover's rule, and give the last meal five or six hours before the operation. In the case of robust adults when the operation is to take place in the early morning, no food need be taken after the overnight dinner. This meal should consist of either broth, strong beef tea, meat jellies, or easily digested foods, varying with the time of the day, and the choice of the patient. Milk, if taken by itself, is very apt to form curd in the stomach, and to be vomited up in the course of the operation in hard masses. This is especially liable to occur in the case of young children. Dilution with barley water will often obviate the clotting. It is not wise to make the administration of stimulants before an anæsthetic a matter of routine. In every instance it is recommended that the bowels be cleared overnight with a laxative, and followed in the morning by an enema. A still better plan is, when the patient is under control for some days before the operation, for the bowels to be cleared out by medicine given on the second night before the anæsthetic is administered, followed by an enema on the morning of the operation. But some surgeons prefer, in the case of abdominal sections, to dispense with purgatives, and give copious enemata daily for a week before operation. Patients are spared much discomfort if they are dieted for a day or two before the operation. Only light nutritious foods should be given. The bowels should be carefully regulated. It often happens that a strong purgative, given the night before an anæsthetic is administered, upsets the digestion, and in bilious subjects increases the after sickness. It is also as well to avoid. as far as possible, interference with the usual hour of the

patient's meals, as food taken when the stomach is not accustomed to it, is liable to remain undigested and to cause vomiting. This is still more important in the case of the weakly or those enfeebled by disease. A prolonged fast, or too free purgation, is very liable to produce syncope and other dangerous symptoms at the time of the operation. In feeble subjects a nutrient enema of beef tea and brandy, or a nutrient suppository may be given half an hour previous to the operation. This is in all cases a better plan than giving alcohol by the mouth.

The following is a condensed form of a useful regimen to be adopted at the time of an operation other than in abdominal cases :—

Operation at 9 a.m.

Beef tea or thin corn flour may be given at 6 a.m. if the patient's condition renders it desirable, otherwise it is better for him to abstain from food.

After the operation at 9 a.m. completed by 10 ; if sickness occur very hot water may be given in sips from a feeder or porcelain spoon. At 2 p.m. essence of beef in jelly ; if much thirst ice may be sucked, or iced soda and milk taken.

If very prostrate from vomiting, iced champagne or brandy and soda water.

At 6 p.m. a light meal of fish, unless the vomiting has persisted.

Operation at 2 p.m.

Breakfast at 8, tea or thin cocoa, bread and milk, fish, but no meat.

Clear soup or beef tea in small quantity (free from fat) if desired, at 11 a.m.

After the operation at 2, over at 3.

Bread and milk, or biscuit and tea or cocoa, at 7 p.m.

Some surgeons feed their patients by nutrient enemata for forty-eight hours after the operation, with the view of lessening after sickness. When this is done it is well to let the patient sip hot water to allay the thirst which otherwise may prove almost intolerable.

When nitrous oxide alone is given, such preparation may be omitted. Even then it is well that an interval of some hours, preferably three or four, intervenes between the last meal and the administration. Fasting for several hours is best for patients who have to take nitrous oxide with oxygen, or chloride of ethyl even when for dental operations, as nausea and vomiting are not infrequent after these anæsthetics. In the case of children especially, it is well to see that they pass water before being anæsthetised, as micturition is often performed unconsciously whilst under the influence of gas.

Preparations for anæsthetic.—Assuming that the physical condition, as far as is necessary, has been examined, the patient about to be anæsthetised should be placed in the recumbent position, except in the case of dental operations under nitrous oxide. The clothing should be carefully loosened, corsets quite undone, neck bands left open, and waist belts removed and strings untied. It is important that the patient be as comfortably posed as circumstances will permit, for while tranquility of mind and body go far to assist in the production of anæsthesia, anxiety and uneasiness will greatly retard its accomplishment. The patient should now be asked to open his mouth, and a glance given to ascertain if any artificial dentures or an obturator, &c., be worn. Such, if present, must be removed with as little annoyance to the patient as possible. It is wise to notice whether any loose teeth are in the mouth, as if it has to be opened with a gag the teeth may be disengaged and enter the air pas-

sages. Any obvious obstruction such as a goitre, enlarged tonsils, hypertrophied uvula, nasal polypi, &c., should be noticed. A further step may be taken in reassuring the patient by a few cheery words, and if necessary, directions as to how he is to take the anæsthetic. Such instructions are often of marked service by giving him something about which to think.

When, however, the anæsthetic is once well on the way, quietness and silence must be maintained; noise—especially in the case of nitrous oxide—militates considerably against easy and tranquil anæsthetisation.

Avoid conversation especially about cases of patients who have died or suffered mishaps. A person going under an anæsthetic is apt to obtain a confused notion that the remarks apply to him and will grow nervous and excited.

Some conditions require special preparation of the patient. In operations for strangulated hernia, intestinal obstruction, and other cases, when constant vomiting is present it is best that the patient's stomach should, if his condition permit of it, be thoroughly cleansed, its contents being withdrawn by lavage and washing out with warm water. This precaution will obviate the fatal aspiration of vomit into the air-passage during anæsthesia.

It is also well when the patient is weakly to wrap him warmly in flannel or cotton wool, as prolonged operation under an anæsthetic usually occasions a considerable fall of temperature and renders the patient more liable to shock, bronchitis, and pneumonia.

The room in which an anæsthetic is given should be well ventilated, but ought to be kept at a temperature of 65° or 70° F. It is undesirable to have gas burning in it as when chloroform is being used that anæsthetic becomes decomposed acid fumes being generated which are not

only very irritating to the eyes and throat but deleterious to the patient and all in the room. It is always best that preparations for the operation be made out of sight and hearing of the patient. It may not be out of place here to insist upon the extreme importance on the part of the anæsthetist as regards **cleanliness.** All **apparatus** should be carefully cleansed before use, and the **hands** and **nails** rendered absolutely clean. Not only is it unpleasant for the patient to see a discoloured hand near his face, but frequently the hands and apparatus of the anæsthetist cannot be kept out of contact with the area of operation and may be a source of **infection.**

It is never desirable to administer an anæsthetic to a patient on his bed, and subsequently carry him into the room in which the operation is to be performed. It is apt to cause vomiting. I have also more than once seen alarming faintness occasioned by lifting the patient on to the table after he was carried from one room to the other. If, however, on account of the patient's extreme nervousness, or for other reasons, it is deemed best to anæsthetise him in an anteroom, the utmost care must be taken in carrying him into the operation room. Adults are best carried by four persons, each taking a corner of the sheet or blanket on which the patient is lying. The same care should be taken in replacing him in bed after the completion of the operation. No patient should be left alone until he has fully regained consciousness, as the state of returning volition has special perils. The dangers to be looked for and guarded against are (1) the head may be rolled into a faulty position and respiration impeded, (2) the patient may become asphyxiated by vomiting when his head is not turned to the side, (3) the patient may suddenly sit up as in the act of vomiting and faint.

Vomit is often very irritating especially if bilious. I

know of one case in which the fluid was allowed to go into the eye, that organ becoming inflamed and painful for some hours subsequently. Possibly the vapour of chloroform which is condensed in the mouth and swallowed may account for the deleterious character of the vomit.

The choice* of an anæsthetic must depend on

1. The condition of the patient.
2. The necessities of the operation.

I. Condition of Patient.

The choice of an anæsthetic in any case can only be satisfactorily made after a careful examination of the patient, and the nature and probable severity of the operation to be performed have been ascertained.

Besides the actual malady for which operation is proposed, it must be ascertained whether intercurrent pathological conditions are present.

Examination of the patient.—The physician who is in charge of the patient can usually give all requisite information about his general condition, but it is desirable that the anæsthetist should have the opportunity of making a personal examination. When possible this should be done the day before the operation, as it is better not to expose or fuss the patient just before he submits to the anæsthetic. The examination should be conducted as quietly and reassuringly as possible.

GENERAL APPEARANCE, POSTURE.

Much can be learnt by inspection. The colour of the skin; whether the lips and ears are bluish or anæmic: pitting of the skin; pallor or plethoric redness are all important

* The question with whom lies the choice of the anæsthetic is considered in detail in Chapter XII.

signs. Alertness, or sluggishness or feebleness in movement betokens vigor or the reverse. The posture naturally assumed must be noticed, as it indicates both the presence of dyspnœa or orthopnœa, and the position which is most favourable for the patient when under the anæsthetic. This is of great importance in cases of thoracic disease, empyema, and kindred troubles—also in cases of abdominal distension, especially when the patient is obese. The eye should be looked at, and dilatation or contraction of the pupils with the ocular movements noticed. It should be ascertained whether belladonna, opium, or other drugs have been taken recently. The detection of artificial eyes is obviously useful. The presence of habits of excessive indulgence in alcohol or tobacco may with advantage be investigated, as the former tends to produce delay and excitement during the induction of anæsthesia, and the latter not infrequently induces pharyngeal catarrh and intolerance towards ether.

A fixed rigid chest with raised shoulders, as a rule, means a dangerous and difficult narcosis, even if no actual bronchitis is present. The plethoric and short necked, and the unduly fat with protruding abdomen, are always short winded and subject to respiratory difficulties under the anæsthetic, being very prone to spasm affecting the respiratory tract. This matter is referred to in a later chapter.

Too much importance should not be attached to the pulse rate. It may run up to 100 or more in nervous people. The regularity in force and rhythm and compressibility are of greater moment, and will give a clue to the condition of the circulation and to the patient's resistive power against shock. Intermittence of the pulse is often congenital and unimportant, and can, if present, usually be explained by the family attendant. In every

case the urine, both as regards quantity and the presence of pathological constituents, must be examined. If the chest and abdomen can be studied, the main points to be observed are: firstly, the general conformation of the chest and its movements; the presence of pulsation and the area of cardiac impulse and dulness; the characters of breath and heart sounds, and if murmurs exist, their character—whether hæmic or not—and the direction of their conduction. The evidence of valvular disease is of less importance than whether the lesion they reveal is compensated or the reverse. If the impulse is feeble and the heart sounds distant, it is well to ascertain, as far as can be done, whether there are further signs of a fatty and feeble heart muscle. Such a condition is of very much greater import than mere intra-cardiac valvular disease unassociated with consequent pathological changes.

Displacement of the heart from whatever cause should be most carefully noted, both because the condition may arise from intra-thoracic causes which are probably detrimental to the respiratory or circulatory functions, or by pressure from the abdomen, a condition possessing its own dangers in the direction of inducing syncope, and because it may evidence dilatation and hypertrophy with probable cardiac disabilities. Inspection of the neck must also be carefully made to determine whether there is any swelling or undue shortness and fulness, and if the veins are normal, dilated, or incompetent. Goitre, enlarged glands, inflamed areas in this region, will often cause respiratory difficulty, and unless a judicious choice of the anæsthetic be made will possibly lead to disaster.

The general inspection having been made, we may consider the condition of the patient more in detail.

The upper air passages and thorax should be examined for any cause of **dyspnœa.** This may arise

from *nasal obstruction*, *morbid growths* blocking the naso-pharynx, *vegetations*, *polypi*, *&c.*; from *hypertrophied tonsils* or *uvula*; *morbid growths* or *œdema* of the *palate*, *fauces*, *tongue*, *gums*, or posterior pharyngeal wall (*e.g.*, spinal abscess) or larynx. In stenosis narium, and especially when associated with valve-like insucking of the muscular lips of the edentulous, inspiration becomes greatly hampered. Goitrous growths and swellings, whether glandular or not, are liable to interfere with breathing, the dyspnœa as a rule increasing as the patient passes under the anæsthetic. Epistaxis may prove a troublesome complication, and any tendency to it should be borne in mind.*

Tumours in the neck or thorax may, by pressure upon the trachea or bronchi, cause dyspnœa, *e.g.*, aneurism, lymphadenoma. Laryngeal œdema obstruction or paresis should be looked for.

Diseased conditions of the *nervous system* may cause interference with respiration through pressure upon the spinal cord or pons, and upon the roots of the nerves associated in the act of breathing. Thus I have on several occasions given chloroform to patients whose respiration was solely diaphragmatic or greatly affected through injury to or disease of the spinal cord, by cerebellar and bulbar tumours. Conditions such as these would induce the anæsthetist to minimise the quantity of chloroform given, as ordinary doses would prove fatal.

Pulmonary and *pleural diseases* are referred to more in detail below. Dyspnœa, accompanied or not with fever, cough, expectoration, hæmorrhage, fixation of the chest, or unequal and impaired movements indicate the avoidance of any anæsthetic or method of giving it which

* The possibility of foreign bodies passing from the alimentary tract into the upper air passages should be remembered. Besides regurgitation of fluids, &c., from the stomach, I have met with a case in which round worms were passed up in this way and caused respiratory obstruction.

might increase the respiratory embarrassment. Ether, if forced, would, for example, almost asphyxiate in such conditions, but chloroform slowly given in a high dilution would be well borne and might in suitable cases be followed by ether from a regulating inhaler.

The colour of the patient is a material point in these conditions as well as when the heart is working at a disadvantage. *Cyanosis*, from whatever cause, increases the risk of the anæsthetic, and every means should be adopted to obviate it. I have found oxygen serves better as an adjunct to ether than to chloroform in dealing with such conditions and in cases of marked cyanosis I have succeeded beyond expectation by using this method.

Besides cyanosis other symptoms, such as the character of the *arterial pulse*, the *impulse* and *apex beat* in the cardiac area, *pallor*, *venous* or *capillary congestion*, *œdema* of the feet, should be noted, that the state of the circulation may be known. The quantity and character of the *urine* must be considered. Both ether and chloroform may increase albuminuria, and ether when given in large quantities and for a long time is liable to set up nephritic catarrh. Whether ether acts as the determining agent or only as a factor in causing suppression of urine after severe operation shock is a moot point. Certainly it is advisable to limit the quantity of anæsthetic given if the kidneys are in any way morbidly affected.

The abdominal viscera.—In cases of "stoppage of the bowels," and of intractable vomiting from whatever cause, the anæsthetist requires to be perfectly acquainted with the condition and to be upon the alert to obviate the dangers incident to the vomiting.

When extreme *thoracic or abdominal distension* exists, *e.g.*, pleuritic effusion, empyema, ovarian dropsy, renal and other tumours, peritonitis with much effusion, there

may be considerable interference not only with respiration but with circulation owing to cardiac displacement. The anæsthetic will in these cases cause increase in the dyspnœa and tendency to syncope unless the greatest care is taken. The suitable arrangement of the position of the patient's body so as to give him the easiest posture for breathing, and the very gradual administration of the anæsthetic will combat these dangers.

ROUTINE IN HEALTHY SUBJECTS.

For all *brief operations*, both in dentistry and general surgery, NITROUS OXIDE GAS may be advantageously given. It can be administered to infants and elderly people as well as to adults. In all conditions in which any respiratory difficulty exists, in cyanosis and in asthenic states, it is well to give it combined with oxygen, but when that method cannot be pursued nitrous oxide with air (see p. 101) gives, in skilled hands, almost as good a result, although at present the methods of administering it are less precise. As an alternative to nitrous oxide, chloride of ethyl or somnoform are valuable anæsthetics for short operations. As they are more liable to produce sickness than is the gas when administered by itself, the choice between the two agents must depend upon whether the risk of vomiting is deemed an insuperable drawback. With chloride of ethyl or somnoform, a longer and somewhat more profound narcosis is obtainable.

Sex and age.—Difference of sex is really simply that of physique and musculature and must be considered under those heads. Ether, either in succession to nitrous oxide according to Clover's method, or following chloride of ethyl, or given by itself, is the best and safest anæsthetic for general purposes alike for adults and children,

and should be adopted as the routine method of producing unconsciousness before operations. There are, however, conditions which are often held as justifying a deviation from this routine, and these are noticed below. It may be pointed out, however, that although apparently a long list, these conditions really represent a very small minority of cases when compared with the great number of instances in which ether should be adopted unhesitatingly.

Childhood.—Infants and young children bear chloroform well, and resent having their mouth and nose covered by a face-piece, an objection, although by no means an insuperable one, to the use of ether. In many instances also ether produces much bronchial irritation in children, so that better anæsthetics in these cases are the A.C.E. mixture, or one of chloroform and ether. I can vouch from personal experience that the plan which Dr. Luke adopts of giving ether by an open method is a good one for young children. The ether is sprinkled upon a Schimmelbusch's or Skinner's mask and held over the face. I have for years used this plan in dealing with feeble anæmic wasted children with success and satisfaction. I have, however, found that in most cases if you can win the child's confidence he will take nitrous oxide well and ether can then be given in succession. Patience rather than force will usually succeed. It is important to give ether lightly as children readily yield to its influence and require little to maintain anæsthesia. When they will not tolerate nitrous oxide or chloride of ethyl, a little A.C.E. mixture or chloroform dropped on a handkerchief will serve to quiet them and as soon as consciousness is lost ether can be substituted. In very prolonged operations the greatest care must be taken that children are not drenched with ether, it is unnecessary and is liable to cause baneful after-effects. I usually give chloroform

from a regulating inhaler in the later stages of a long trying operation on children, even when they are rendered anæsthetic with gas and ether or ether. This is to avoid the cooling which ether produces and which is especially deleterious in the case of the young.

Children of about five or six years of age may be given gas and ether, unless they are notably the subjects of respiratory trouble. They will probably strongly rebel against having the face-piece applied, so that if it be desirable to avoid "a scene," the mixtures of chloroform, alcohol and ether, may be substituted and given by the open method. Ethidene dichloride is advocated for children by some, but experience proves that it is not taken more readily and does not appear to be in any way safer in its action than chloroform. Although the use of chloroform is unquestionably attended with happy results in the case of children, it must be remembered that deaths from this agent are by no means confined to adults. It cannot, therefore, be too strongly impressed upon the mind that children run a risk, and probably as great a risk, in chloroform narcosis as do adults. Children take chloride of ethyl well, although they are often alarmed by the tightly fitting mask necessary for its administration.

For the **aged,** that is for those over 60 years of age, chloroform is commonly held to be preferable to ether and in many instances such is the case. It is, however, true only because persons past middle life are often the subjects of chronic bronchial trouble; their arteries and kidneys are also frequently diseased and so may be injuriously affected by ether. Old persons too, like infants, are peculiarly susceptible to a bronchial and laryngeal irritability inducing distressing cough, dyspnœa and exhaustion. However, for aged and feeble subjects with weak hearts and depressed vitality, ether, notwithstanding

the above mentioned drawbacks, is beyond doubt the best anæsthetic. It often happens that when cough is at first excited by ether the administration of a few inhalations of chloroform will remove all dyspnœa and allow the subsequent employment of ether. In a certain number of cases ether proves an impossible anæsthetic for the old, however carefully it may be administered, and such cases must be recognised and dealt with on their own merits, chloroform being substituted. Although advanced age in itself does not contra-indicate the use of nitrous oxide gas before ether, in some cases, *e.g.*, tendency to high vascular tension with feebleness of circulation, chloride of ethyl or a little A.C.E. mixture may be employed in its stead as an antecedent anæsthetic to ether.

In **middle age**, when the patient is vigorous and muscular, ether preceded by nitrous oxide gas or chloride of ethyl should be employed, as this prevents struggling, and rapidly and pleasantly produces anæsthesia.

Pregnant women take all forms of anæsthetics well, but if excitable and nervous as they are apt to be, it is better to avoid the coughing and straining which may follow the employment of ether. It will be found that unless very nervous, women in this condition take nitrous oxide followed by ether well, as little of the anæsthetic should be given as is consistent with true anæsthesia, as it is manifestly important to avoid vomiting. An anæsthetic should not be given to a woman pregnant over eight months unless the operation is imperative. If, however, the surgeon must operate, there is no valid reason why the anæsthetic should not be given. I have administered to ladies in the ninth month of pregnancy without untoward results. When women are very prone to abort, it is well, if possible, to defer any operation and the giving an anæsthetic during pregnancy. Whether the nervousness and general

upset are not as much factors in producing abortion in such cases as the anæsthetic may be questioned.

CHOICE OF ANÆSTHETIC IN DISEASE.

The **imbecile, lunatics** or **persons in delirium** can be given anæsthetics and take gas and ether easily. It is well known that any disturbance of the cerebral circulation is liable to super-induce attacks of mania in persons who have once been maniacal, and so taking chloroform or ether may produce such an attack. It is not by any means always so, as far as my experience goes, and I have notes of very numerous cases of anæsthetics given to the insane.

Alcoholism.—Persons addicted to alcoholic excess take anæsthetics badly. They usually show excessive restlessness, become much excited and require a large amount of the anæsthetic to render them unconscious. Such persons are best given nitrous oxide followed by ether, but they often become greatly cyanosed, and to relieve this condition chloroform must be given for a time, even if ether be subsequently resumed. As a rule, oxygen given with the ether prevents this cyanosis unless it is due to severe spasm. I have found that some confirmed alcoholics remain restless and rigid even during profound narcosis.

Respiratory tract.—*Larynx, trachea, bronchi, lungs and pleural cavity.* Intra-laryngeal disease demands chloroform, and the same may be said of the trachea and bronchi, when the affection is acute and the dyspnœa urgent. In *diphtheria*, chloroform alone or combined with ether, usually gives a satisfactory result. When the asthenia is very severe it is safest to use a Schimmelbusch's

mask and drop chloroform and ether upon it. The ether is used from time to time to assist the circulation, without impeding respiration. In *bronchitis* and *lung disease*, when much *cough and dyspnœa* exist, ether is seldom well tolerated. If used at all it must be given from a semi-open inhaler such as an Allis, or dropped upon a lint covered frame (Skinner). In these cases if the patient cannot bear some mixture of ether with chloroform such as the A.C.E. it is best to obtain anæsthesia by means of chloroform. Ether or a mixture may be tried when anæsthesia is established, but if ill-borne, chloroform must again be employed. As a rule, chloroform from first to last is the best and safest anæsthetic when the lungs are the seat of acute or active disease. In *pneumonia* or *œdema of the lungs* ether should not under any circumstances be given, as it tends to embarrass the lungs still further. Chloroform may, however, be used, but must be largely diluted with air or still better with oxygen. *Phthisical persons* when the coexistent bronchitis is not severe and cough and expectoration are not prominent symptoms, as a rule, will take nitrous oxide and ether without discomfort or detriment. When, however, ether excites cough and causes distress chloroform must be substituted. *Bronchitis* when associated with *emphysema* often causes extreme intolerance of ether, but the A.C.E. mixture, or failing that, chloroform, will usually suit this condition. When *emphysema* is the most pronounced symptom a difficult problem is presented. There is in most instances a dilated and weakly heart associated with it, and any anæsthetic may lead to dangerous consequences. Ether will in a few cases set up severe cough, spasm, and almost asphyxiate the patient. On the other hand, if chloroform is used there is always a danger, unless extreme care is taken that an overdose may be

given, owing to the failure of expiratory power in the lungs and the fixation of the thorax. The dyspnœa, spasm, and cyanosis set up by the ether will often disappear at once when the ether is replaced by chloroform. The adoption of the A.C.E. mixture in the later stages of the case, and care that the chloroform vapour be given very dilute, will usually bring the administration to a successful conclusion. It is in such cases that the chloroform apparatus of Mr. Harcourt affords the most valuable aid, as it enables the administrator to limit with exactitude the percentage of vapour at any stage of the narcosis.

Asthmatics as a rule take the A.C.E. mixture or chloroform better than nitrous oxide or ether, but when the initial stage of anæsthesia is passed, if but little bronchial secretion is present, ether will be well borne.*

If fluid exists in the pleural cavity as in *pleurisy with effusion* or *empyema*, especially when the heart is mechanically much displaced, anæsthetics are badly borne. This arises more from the posture which the operation necessitates—commonly one which the patient if conscious would be unable to assume owing to cough, dyspnœa, and failure of the heart's action—than from any inherent action of the anæsthetic. In cases of pleuritic effusion, and when an empyema does not communicate with the lung, if the patient can tolerate ether there is no reason why he should not take it while the initial and only painful part of the operation is performed. Usually, however, too much cough and spasm follow the use of this anæsthetic in these cases, so that the A.C.E. mixture or some other dilution of chloroform has to be employed. In my own practice I am in the habit of employing chloroform for all cases of lung and pleuritic disease, and have convinced

* It has been pointed out by Mr. Tyrrell (*Transactions of Society of Anæsthetists*, March, 1898), in many, ether relieves asthmatic seizures.

myself that, upon the whole, this anæsthetic is the safest. The use of nitrous oxide and oxygen for operations for empyema has not any advantage over chloroform, and frequently causes very grave dyspnœa and cyanosis. In any case the lighter the anæsthesia is, the better are the chances of the patient.

It is often requisite to decide what anæsthetic will be best for persons subject to *oft repeated attacks of bronchitis and bronchial catarrh*, even though they may be quite well at the time of the operation. If in such cases the attacks are easily excited and liable to endanger the patient's chances of recovery, ether will be best replaced by a mixture or by pure chloroform. I think that when some inhaler, such as Mr. Harcourt's, is used, so that the dose of chloroform can be kept strictly at or below two per cent., there is no doubt that, for all persons whose lungs are affected, chloroform is the best anæsthetic. When, however, chloroform is given in higher percentage it is often dangerous and should be avoided. Of course the general state of the patient must be taken into account, and the possible arguments against the use of chloroform receive due consideration.*

I have found from the experience of the past few years that ether can be often taken well and borne without bad after effects, in cases of lung and pleural disease, when it is administered well diluted with oxygen, and provided the operation is not a prolonged one such as would necessitate the inhalation of a large quantity of the anæsthetic. Much of the cough, cyanosis, and distressing struggling which usually accompany the attempt to administer ether to persons suffering from dyspnœa, is caused by spasm set up by the ether. This spasm is at once relieved

* M. Lépine has shown that if the ether is pure, and it is given with care bronchitis is not increased by its use.

when the ether is given with oxygen, the patient rapidly passing into profound anæsthesia without further trouble. The oxygen further stimulates the circulation, steadying and improving the action of the heart.

I have in some very bad cases of pulmonary embarrassment employed rectal etherisation with success.

Diseases of the circulatory system.—Although the existence of heart disease and vascular irregularity should materially influence the choice of the method in which an anæsthetic should be given, it very seldom vetoes the use of general anæsthesia. As Snow said—"If a patient is able to undergo an operation, he will not be an impossible subject for an anæsthetic."

In **mitral disease** when the pulmonary circulation is interfered with, and some cyanosis and possibly slight œdema with cough and dyspnœa exist, ether usually increases the distress. The employment of chloroform preferably diluted as in the A.C.E. or Billroth's mixture, frequently steadies the heart. It is well to give such patients a course of digitalis before the operation, or a hypodermic of digitalin or strychnine half an hour previous to the anæsthetic. The mere presence of a mitral murmur, without symptoms or failure of compensation, need not deter from the use of nitrous oxide and ether. Some authorities prefer to commence with the A.C.E. mixture, and in such cases, if it can be borne, to give ether as soon as anæsthesia is established. I have found oxygen a valuable adjunct to the ether in all cases when cyanosis existed, and when the presence of œdema of the lungs did not contra-indicate the use of ether. The state of the pulse should always be noted before an anæsthetic is given, both as a guide to the condition of the patient's circulation and also for comparison in the subsequent stages of the anæsthesia. The various causes of pulse variation must in this

connexion be remembered,* and the share which respiration, cardiac action, alteration in capillary resistance and renal adequacy, and various cerebral conditions, take in affecting the rhythm, force, and frequency of the pulse, should be duly appreciated. It must be remembered that in all cases of pulmonary disease, whether primary or following mitral disease, there may always be a danger when ether is given for any length of time, lest water-logging of the lungs or œdema should arise as a later and dangerous sequela of that anæsthetic. It is, therefore, my custom, even when I commence the inhalation with nitrous oxide and ether, to change to chloroform if the operation occupies any period of time exceeding half an hour.

In **aortic disease** there is a special danger from struggling, and a liability to syncope. I have found persons so affected take nitrous oxide and ether well, but care should always be exercised to avoid any undue straining or struggling. The merit of nitrous oxide gas, preferably with oxygen, given before ether in these cases is that the stage of struggling is avoided. These subjects also, as a rule, take chloroform well, and this or a mixture of it with ether can be given instead of the gas, while ether can be employed in the later stages. Such patients, it must be remembered, are peculiarly liable to syncope as they are resuming consciousness, and the most sedulous care should be taken to prevent them from sitting up, either during the administration, or until the effects of the anæsthetic have quite disappeared. As they pass from under the influence of the anæsthetic they retch or vomit, and these acts are often accompanied by an alarming fall of blood pressure. In all forms of heart disease it is safer

* See "The Pulse," by Sir William Broadbent, Bart., M.D., F.R.C.P.; and "Pulse Gauging," by G. Oliver, M.D., F.R.C.P., may be consulted with advantage in this connexion.

to administer slowly and warily, and to maintain a fuller dilution with air than is at all necessary in ordinary cases.

Degenerations of the myocardium.—When the heart muscle has undergone structural changes, the danger of producing anæsthesia is greatly increased. Any alteration in the respiratory or vascular systems induced by anæsthetics imposes an extra strain upon the already weakened and diseased heart—one which it may be unable to sustain; hence supervenes syncope. There seems also a danger, as Dr. Leonard Guthrie has pointed out, that chloroform may itself in the case of children induce a degeneration in the heart muscle, a grave condition when superadded to initial disease. When the heart trouble is not complicated by pulmonary engorgement, œdema or hydrothorax—when it is in short largely compensated—ether should be given and a Clover's inhaler employed. I am in the habit of using oxygen with ether in these cases, and find it materially assists the patient and I think lessens the danger. It has been suggested that a cone or towel is safer, but I cannot think this is so, since with a Clover's inhaler you can, by frequently removing the mask or refilling the inhaler bag, give any degree of dilution of ether you require. When pronounced pulmonary trouble exists and ether cannot be borne, chloroform or the A.C.E. mixture may be given.

Should nitrous oxide be administered in MORBUS CORDIS? I have records of practically every form of heart disease in patients to whom I have repeatedly given anæsthetics, and in those in whom no pulmonary disease coexisted, nitrous oxide has caused no alarming symptoms. The complication of cyanosis and lung trouble with a dilated weak heart is a grave one. Sometimes nitrous oxide with oxygen is well taken, even by persons so afflicted, but there is no small risk, and the greatest care and experience

are needed to bring the case to a satisfactory issue. If the case is one of advanced disease and the organ is working feebly, it is wise to supplement the nitrous oxide by allowing it to pass over ether vapour. This plan has in my hands answered most admirably.

Chloroform, whether pure or diluted, cannot be given to persons having diseased hearts without increasing the risk of syncope, due to the unavoidable fall in blood pressure which follows the use of this anæsthetic. This fall, however, can be minimised by using only low percentages of chloroform vapour. On the other hand, it must be remembered that in these cases the anæsthetic is in a way protective. As Snow pointed out, chloroform "when carefully administered causes less disturbance of the heart and circulation than does severe pain." In this connection it should be borne in mind that shock very often killed in pre-anæsthetic days, and it is not too much to say that if chloroform is ever the cause of death when properly administered, it is certainly very often the means of saving life by protecting from pain and shock.

Hypertrophied hearts are in practice usually *dilated* hearts, and being so are at a disadvantage. The same rules given for guidance above will serve here. Some highly nervous, excitable persons are much terrified by the application of a face-piece, and indeed in some few cases the mental distress and terror thus excited may be sufficient to occasion serious indisposition. In cases such as these it is especially useful to employ the A.C.E. mixture upon lint or dropped upon a Schimmelbusch's mask, replacing it by ether from an inhaler so soon as the patient is sufficiently dazed not to perceive the substitution.

Vascular disease. *In arterial disease.* In aneurism and extensive disease of arteries it is best to use chloro-

form or one of the mixtures containing it, to avoid the increase of blood pressure induced by ether in the initial degrees of anæsthesia. It is quite safe to give ether after the patient has been thoroughly anæsthetised and has been unconscious for some little time.* When apoplexy has previously occurred, or its onset is feared, ether had better be avoided and chloroform given. Cerebral hæmorrhage is reported to have occurred after ether had been inhaled, but the probability of such a result is slight. The danger in all cases of vascular disease arises from struggling and the consequent interference with the circulation. It is therefore most important to adopt such methods of giving the anæsthetic as will prevent or lessen the stage of excitement. This is most perfectly done by the use of nitrous oxide followed by ether, if this mixture be employed with judgment.

Renal disease.—Ether is said to produce albuminuria and even cause suppression of urine. Lawson Tait recorded a case in which ether appeared to stop the flow of urine along the exposed ureter. Turnbull† says, that Emmet of New York met with six cases in which suppression of urine occurred after operations under ether in persons with chronic nephritis. Professor Wood, of Philadelphia, also found cloudy swelling of the nuclei and contents of the secreting renal epithelium after etherisation of dogs. On the other hand Eisendrath, Barensfeld,

* I have notes of a very instructive case bearing upon this point. The patient suffered from popliteal aneurism for which it was proposed to tie the femoral. He was given nitrous oxide and ether, and narcosis was rapidly attained without struggling. Upon the patient being brought into the operating room the aneurism was palpated when all pulsation was found absent. The case was cured without any operation. No doubt the increase in blood pressure had led to disturbance in the circulation which luckily had resulted in clotting and filling up of the sac. Had, however, the other result occurred and the clot been conveyed to the heart the choice of the anæsthetic would have justly been considered a fatal mistake.

† "Artificial Anæsthesia," 4th edit., 1896, p. 225.

and Campbell of Montreal, found in human subjects that albuminuria was the exception after ether when non-existent previously, and that in pre-existing albuminuria a slight but transient increase followed prolonged etherisation. This conclusion is fully in accord with my own experience. Chloroform is more liable to initiate* albuminuria according to these observers. With the assistance of Dr. Levy I investigated this subject, and our conclusions may be stated briefly as follows†: in most cases the quantity of the urinary water was reduced in quantity, but probably not more so than could be accounted for by the abstinence from food and liquids. The solids remained practically unaffected. When ether is given in excessive quantity ischæmia of the kidneys is produced and albuminuria results. If, however, only so much is inhaled as is needed for complete anæsthesia no deleterious results arise, and the renal parenchyma is not injured nor does albuminuria result. The experimental work was supplemented by the study of clinical cases and these bore out our experimental deductions.

In **conditions of collapse,** *e.g.*, railway smashes, gunshot wounds, intestinal obstruction due to strangulated hernia, or other causes, ruptured viscera, or conditions when the vitality has sunk very low, as in the case of carcinoma affecting the œsophagus, pylorus, and causing chronic starvation; also in collapse the result of severe hæmorrhages or other causes, or provoked by high temperatures, it may be necessary to perform an operation, and it will usually be desirable to administer an anæsthetic. Ether if properly administered is, I am sure, the best and safest anæsthetic for these cases. It may be

* See "Complications of Ether," Chap. IV.

† *British Medical Journal*, Sept. 22, 1900, "The effects of inhalation of certain anæsthetics on the kidneys."

given from a Clover's inhaler, as when that apparatus is properly handled there need be no dyspnœa or impediment to respiration. Very little anæsthetic is required, and the mask may be taken off during inspiration every three or four respirations. When there is very considerable respiratory difficulty complicating the case, the A.C.E. mixture may be employed. Still ether is *par excellence* the anæsthetic for such patients. It is important to give plenty of air, and only to administer the ether intermittently as necessity seems to require. I have found the use of oxygen with ether most valuable under such circumstances. In extreme collapse, *e.g.*, railway smashes, the possibility of serious internal lesions and hæmorrhage must be kept in mind, as the incautious deepening of the anæsthesia may, under such circumstances, lead to serious results. A possible danger from ether in these cases arises when by increasing blood pressure internal hæmorrhage is initiated. When the breathing is feeble and gasping, and the patient almost *in extremis* with blue livid skin and pulseless, I employ ether dropped freely from a drop bottle upon a Schimmelbusch's mask covered with two layers of lint, keeping up a supply of oxygen by a mouth or nose tube. In cases of intestinal obstruction, when extreme collapse is present, I select ether and oxygen, if, however, collapse is less marked I prefer chloroform. In either case extreme care in regards to the posture of placing the patient is requisite to avoid the regurgitation of intestinal fluid being aspirated into the lungs.

II. The Necessities of the Operation.

Operations about the head, neck, face, trachea, and respiratory tract.—In all cases of

interference with respiration due to swelling of the structures of the neck, *e.g.*, angina Ludovici, enlargement of the thyroid, in cervical lymphadenoma with pressure, nitrous oxide is contra-indicated. Ether usually causes increased dyspnœa, and so is best avoided. Chloroform given with great care is safest and best for the operator. Brief operations about **the mouth, nose,** or **pharynx,** such as the extraction of teeth, excision of tonsils, opening of abscesses, snaring off mucous polypi, &c., can often be performed under nitrous oxide,* or chloride of ethyl. With nitrous oxide, from a half to one minute of unconsciousness can be expected. In operations slightly more prolonged, chloride of ethyl, and if the cautery is not to be used, gas with ether may be employed. In operations accompanied by severe hæmorrhage, but which do not need much time, the gas and ether mixture possesses the advantage that the patient rapidly resumes consciousness, and so the danger of blood being drawn through the trachea into the lungs is avoided. In operations for the removal of **post-nasal adenoid growths,** I have for some years extensively used gas and ether with success, the patient being placed in the sitting posture. It has been urged by many that nitrous oxide gas, alone or with oxygen, is a sufficient anæsthetic for the removal of post-nasal adenoid growths. This may no doubt be true for a certain number of cases, but there is a danger that the brief anæsthesia which children experience under it may prove insufficient, and so undue haste may be forced on the surgeon, and the little patient may feel the finishing steps of the operation. When tonsils have to be removed at the same time as the post-nasal adenoids, it is a good plan to give nitrous oxide

* The precise way in which nitrous oxide should be given, *e.g.*, with oxygen, air, &c., will be dealt with in Chapter III.

followed by ether, and when complete anæsthesia is obtained the operation may be proceeded with, and chloroform can be blown in vapour through a tube connected with a Junker's apparatus. Thus anæsthesia can be maintained as long as is needful. For this method the patient must be lying in the horizontal posture. Chloride of ethyl answers very well for uncomplicated cases of the removal of tonsils and post-adenoid growths, but as the narcosis produced by this agent is very profound although transient, care must be taken to place the patient in such a position that the effused blood cannot be aspirated into the trachea.

For most intra-nasal operations I have found nitrous oxide and ether satisfactory. It may be necessary in very prolonged cases to give more than one inhalation of ether, but there is no objection to this if care be taken, by turning the head to the side, that blood does not enter the lungs. When the patient is sitting up, I bend the head and shoulders forward during the reapplication of the ether. It is better not to wait for a return to consciousness before giving the second inhalation. When the surgeon wishes his patient to be seated, chloroform should not be given. Snow, it is true, believed that the sitting posture was as safe as any other, but there can be little doubt that in such a position the heart works at a disadvantage, and cerebral anæmia is very prone to occur. Some surgeons prefer chloroform for all patients when the naso-pharynx is the seat of operation, since they allege this anæsthetic produces (i.) a more profound and lasting anæsthesia, and (ii.) because less violent bleeding takes place at the time of the operation. On the other hand, the rapid resumption of consciousness under ether certainly minimises the danger of blood entering the lungs. When the operation is likely to prove a prolonged one, chloroform will be more

satisfactory to the operator, but the patient must be in the recumbent position.

Staphylorraphy necessitates the mouth being open, and that the operator should have free and uninterrupted access to the buccal cavity. To effect this, the patient can be put under the influence of chloroform, and maintained so by anæsthetising through the mouth by means of a tube (as described in Chapter V.). The same procedure answers for operations about the **tongue.** For the removal of small growths from the tongue, lips or from the gums I have found nitrous oxide answers well. The method of prolonged nitrous oxide administration through the nose, gives the operator a much longer period of unconsciousness. (See also Chapter IV.).

In Kocher's operation for the **removal of the tongue,** ether can be used when it seems desirable until quite the end of the operation when the mucous membrane of the mouth is opened and the tongue dragged into the incision.

Removal of the upper jaw should as a rule be performed under chloroform, as the cautery is often requisite and the use of a face-piece impossible. In extensive removals of growths about the jaws, it is frequently advisable to perform a preliminary tracheotomy, and then give the anæsthetic through a Trendelenburg's tube, at the same time plugging the larynx. It is, however, quite possible to obtain a most satisfactory anæsthesia with ether, which allows removal of either jaw (see Chap. IV.). I have occasionally used ether in these cases with success, and I am informed this method is employed as a matter of course in some cliniques in the United States.

In the **removal of the lower jaw,** ether may also be used for the earlier stages of the operation, chloroform being substituted when the mouth has to be opened.

In any case when the cautery has to be used the ether must be replaced by chloroform.

Operations upon the **larynx,** *e.g.*, **thyroidectomy,** will require a preliminary tracheotomy, and in these cases I prefer to keep up the anæsthesia by a Junker's inhaler, to the afferent tube of which is fixed a catheter. By this means the amount of chloroform given can be more safely adjusted than when a Hahn's tube and funnel are employed. In all the above cases in which chloroform is mentioned as being more convenient, an alternative method exists, namely, rectal etherisation.

Operations about the **eyes** are commonly performed with the aid of cocaine, eucaine, or some local analgesic (see Chap. XI.); when general anæsthesia is decided upon, and it is often necessary in the case of children and excitable nervous or asthenic persons, it is important to obtain deep narcosis. These cases require absolute immobility, freedom from coughing being essential. Nitrous oxide and ether, provided the ether be pushed very far, answer well; there is of course the possibility of ether exciting a fit of coughing, which, should the case be one of excision of a cataract, and should a preliminary iridectomy have been already done, may lead to forcible extrusion of the vitreous. But this can only arise when the patient is not sufficiently under the anæsthetic. There is less fear of coughing with the use of a chloroform and ether mixture. I have used the oxygen-ether method very satisfactorily for these cases. Upon the whole I think when the patient is old and feeble and the respiration in any way impaired by former attacks of bronchitis, that chloroform offers the best chance of a successful operation.

In **excision** of the **eyeball,** where coughing is not of such moment, ether may be used, and should be pushed to complete anæsthesia before proceeding with the opera-

tion. For passing probes or slitting up the lacrimal canals, gas is not as a rule satisfactory, as the jactitation interferes with the operator; here the use of ethyl chloride or gas and oxygen answers every purpose by obviating involuntary movements.

For **operations** about the **thorax,** a mixture of chloroform and ether is by some authorities considered to be more advantageous than chloroform or ether when given alone, so that where the ether contained in it can be tolerated by the patient, this mixture should be employed. For paracentesis in cases of pleuritic effusion chloride of ethyl or nitrous oxide gas is sufficient. Chloroform, unless a very low percentage vapour is used, seems peculiarly liable in cases of empyema to dangerous results, the heart is usually hampered and respiration abnormally performed; several deaths have resulted from chloroform given in such cases. When the bronchial tubes are not blocked with pus and no communication exists between the abscess and the bronchi, ether will occasionally be well borne, but as a rule a low percentage chloroform vapour is, I think, safer.

It is in these operations that rectal etherisation seems likely to be of very great service. (See Etherisation by the Rectum).

Abdominal Surgery.—In dissecting operations, when tranquility of respiration is desired, as in operating for the radical cure of hernia in young children, some mixture of chloroform and ether may be employed instead of ether, but for all prolonged and exhausting operations ether should be given unless strongly contra-indicated. Thus I have found for Cæsarian sections, ovariotomies, hysterectomies, ether if carefully given answers very well. It is undesirable to continue the ether for more than forty-five minutes or an hour unless the patient cannot

take chloroform. After this time a chloroform ether mixture or chloroform may be used.* If one kidney is presumably adequate and healthy, ether may be used in nephrectomy. For operations upon the liver and gall bladder, for those upon the intestines and stomach, chloroform or a chloroform ether mixture makes the operation easier for the surgeon, and subjects the patient to less risk of pulmonary complications. Still with care in the use of ether such operations can be performed when the patients' state seems to contra-indicate the employment of chloroform.

In Labour.—There is a consensus of opinion in favour of chloroform in these cases, but chloroform cannot be in any way deemed more free from danger in childbirth than at any other time. If chloroform be employed it should not be entrusted to the hands of a nurse or other person unless skilled in its use. The mixtures of chloroform and ether also answer well. Ether, though advocated by some, is disadvantageous in these cases, as it may provoke straining, coughing, sickness, and headache,† but for general obstetric operations, and especially where the patient is exhausted and needs stimulating, ether is indicated.

Although no experimental evidence exists so far as I know for the statement, yet it is commonly asserted that chloroform is safer for the child than ether. A point worth remembering is this, that the more agreeable smell of chloroform and its rapidly soothing effect makes the patient inhale it freely as the pains are coming on without any holding of the breath.

* It is alleged that ether pneumonia is especially liable to occur in abdominal operations. See "Ether Pneumonia," by Dr. David Drummond, *Brit. Med. Jour.*, Oct. 1, 1898, p. 939.

† In my private practice I have met with cases of women who after trying chloroform preferred to take ether in their confinements, stating that it produced more exhilaration and general feeling of well being, while it assuaged their pangs more efficiently than chloroform.

CHAPTER III.

NITROUS OXIDE GAS.

Chemical and Physical Properties.—Nitrous oxide gas [N_2O] is a colourless body possessing a slightly sweet taste and ~~colour~~, sp. gr. 1·527. It possesses a neutral reaction and consists of nitrogen and oxygen in chemical union, thus differing from the air, which is composed of these gases in mechanical mixture. Nitrous oxide gas possesses well-defined anæsthetic properties, which appear to be quite distinct from the asphyxial symptoms frequently accompanying its administration. This gas agrees with oxygen in many of its chemical properties; thus, it supports combustion when ignited bodies are plunged into it. At a pressure of fifty atmospheres and a temperature of 44·6° F. (7° C.), it becomes liquefied, and advantage is taken of this to enable the gas to be carried about in iron or steel cylinders, these latter occupying less space. Liquid nitrous oxide, sp. gr. ·936 at 0° C., is colourless, and mobile; it has the lowest refractive index of all fluids. Fifty gallons of the gas are yielded by fifteen ounces of the liquid nitrous oxide. It is extremely sensitive to heat, undergoing rapid expansion as its temperature is raised. This is a point of practical importance, as cylinders of this gas are liable to burst if subjected to heat, indeed this accident has occurred.

Nitrous oxide is decomposed at a red heat, but shows no tendency to undergo change at lower levels of temperature. Cold water dissolves more than its own volume of

this gas, while hot water dissolves less, hence it is advantageous to collect it over water at 15° C. Alcohol takes it up in a still larger proportion.

Increased pressure causes nitrous oxide to assume the solid form. It is then white and snowlike in appearance. It has long been known that if the gas from an iron cylinder be allowed to escape suddenly, it assumes the solid form and may block the outlet. This is more liable to occur when the cylinders are placed horizontally, but by the use of cylinders suggested by the late Dr. C. E. Sheppard, who has the exit tube placed so that its inner end is above the level of the liquid nitrous oxide this drawback is obviated.*

It is prepared by heating granulated nitrate of ammonium to 460° F., and collecting over water.

The impurities to which nitrous oxide is liable are :—

Chlorides, possible impurities in the ammonium nitrate used in its manufacture ; other oxides of nitrogen ; and oil (from lubrication of apparatus) which impart a rancid, nauseous smell to the gas.

To test for these impurities, let the gas bubble through solutions of nitrate of silver, which will precipitate chlorides, while the other adulterations will be detected by their smell and irritating effects on the throat. In nitrous oxide which has been kept in a gasometer for some time there is always some atmospheric air.

Some persons prefer the freshly prepared gas, but liquefied gas stored in cylinders gives results practically as good.

* See Dr. Sheppard's paper, *Lancet*, Feb. 21, 1891.

Physiological Action of Nitrous Oxide.

For many years the true nature of the action of this gas upon the organism was misunderstood. Various theories, now known to be erroneous, obtained credence mainly owing to unreliable methods of experimentation and for a long time a limit to the uses of nitrous oxide was thus imposed, as the agent was regarded as alike dangerous and untrustworthy.

It is only necessary to refer to the theory which taught that nitrous oxide produced anæsthesia by hyperoxidation, to refute it. Nitrous oxide is not an oxidising agent as it does not split up in the organism. A more dangerous view advanced was that nitrous oxide exercised no specific action but mechanically displaced oxygen from the lungs and so lèd to tissue asphyxia. The late Sir George Johnson following the remarkable experiments of Dr. John Reid, was led to the conclusion that nitrous oxide, by producing deoxygenation of the blood and tissues, set up arterial spasm both in the systemic and pulmonary vessels. The increased resistance to the blood flow thus brought about, led he thought, to lividity, failure of the radial pulse, and finally through cerebral anæmia to epileptiform convulsions. Dr. Amory, of Boston, also held this view. Professor H. C. Wood* assisted by Dr. David Cerna has made important observations on this subject. Their paper must be consulted for details, their conclusions alone can be briefly noticed here. They regarded the action of nitrous oxide and nitrogen as similar, but found that nitrous oxide produces anæsthesia probably more rapidly, and does so by "shutting off the oxygen."

* *Therapeutic Gazette*, August, 1890.

Although no reference is made to my experiments, the conclusions with regard to the circulation of the blood under nitrous oxide are very strikingly in accord with mine. "It would seem," it is said, "as though nitrous oxide acts upon the heart and nervous system directly, but has little or no direct inherent influence upon the vaso-motor centres or the brain cortex." In comparing the effects of these gases with the effects brought about by asphyxia, it is admitted that the resemblance, which so many preceding observers had erroneously regarded as identical, is only noticeable to a certain extent.

In most researches undertaken to elucidate the effects of nitrous oxide, a point of great importance has been overlooked. If oxygen is excluded for too prolonged a period, of necessity the phenomena of oxygen deprivation will make themselves manifest. If, as has been assumed, no anæsthesia can result until this oxygen starvation exists, the question is settled, but such is not the case. Indeed the classical experiments of Paul Bert proved this. I pointed this out in my research, undertaken in 1885, and Wood and Cerna have since then undertaken experiments with nitrous oxide mixed with oxygen. If the supply of oxygen is carefully regulated the most profound anæsthesia associated with normal pulmonary and systemic circulation results. Under these circumstances no question of tissue deoxygenation arises, so that it must be admitted that however asphyxial symptoms may, through want of expertness, play a part in some forms of nitrous oxide anæsthesia, yet the gas in question certainly possesses a specific effect upon nervous tissue and exerts that influence through the blood. Having attempted to show this it will be well to pass into more detail concerning its action on the tissues.

Nitrous oxide appears to suspend rather than extinguish

vitality. Seeds will not germinate but remain uninjured when kept in it an indefinite period. Seeds, if sprouting, cease to develop when placed in an atmosphere of this gas, but resume their growth when again placed in the air. Jolyet and Blanche found that plants placed in nitrous oxide gas cease to absorb carbonic dioxide, and do not increase in size. When oxygen is allowed to mix with the nitrous oxide the seeds germinate, and the plants grow. Cold-blooded animals die in an atmosphere of nitrous oxide in about two hours. This contrasts with what obtains when the same creatures are placed in indifferent gases, such as hydrogen or nitrogen, for under these circumstances death does not occur for three hours, and is preceded by stupor but not true analgesia. Kappeler has shown that frogs placed in nitrous oxide lose reflexes after a very few minutes, whereas the reflexes persist for several hours when the frogs are placed in an indifferent gas, *e.g.*, nitrogen (Goldstein). Sir Humphry Davy, in his careful research, showed that small mammals and birds soon die in nitrous oxide, although when it is mixed with oxygen they live until the oxygen tension sinks to six per cent., as against a carbonic dioxide tension of twelve per cent.

Animals placed in non-respirable indifferent gases become convulsed before death; this does not obtain when they are made to respire nitrous oxide, provided asphyxial conditions are not present. Their respirations simply grow more and more shallow, and finally cease without any of that *besoin de respirer* which is elicited when simple deprivation of oxygen is practised.

Krishaber experimenting with rabbits found a marked acceleration of the rate of the pulse, with increased force at first in the heart beat. Subsequently when anæsthesia was determined some retardation occurred, while the

cardiac rhythm became less regular. Respiration was accelerated, and death resulted in two or three minutes. He performed control experiments by ligaturing the trachea. In these, cardiac rhythm remained unchanged until after the fourth minute, when the heart beats grew irregular, and ceased at times varying from seven to eleven minutes. The animals remained sentient to the very last. I have repeated these experiments, using dogs and cats in preference to rabbits, because these last are peculiarly liable to fright, and this disturbs the rhythm alike of the heart and respiration, and in the main my results agree with Krishaber's. While dogs die in from two to three minutes in nitrous oxide, they do not succumb to asphyxia for five; under nitrous oxide they grow wholly insentient in from fifteen to thirty seconds, while in asphyxia consciousness to pain only ceases with life. Under nitrous oxide I found the heart little affected until the respiration was gravely interfered with, in other words until asphyxial conditions were present, and then it gradually failed before totally stopping. The creatures seemed under the gas to sink into sleep, and from sleep to pass into death, while when asphyxiated they struggled from first to last.

In the human subject.—It is probable that nitrous oxide when administered pure, enters the blood by diffusing through the thin walls of the air-cells in the lungs. In the blood, a small quantity is dissolved, but the bulk is connected in some loose way with the blood constituents, probably being associated more or less closely with the albumins and albuminoids of the liquor sanguinis and corpuscles. Pickering has, in an interesting research, corroborated the view which was suggested by me in the papers referred to below, that nitrous oxide is taken into a loose association with the hæmoglobin of the blood. The

whole question of the physiological action of nitrous oxide has been recently reopened by Dr. G. F. Kemp, of Baltimore, but as his conclusions are in accord with my own,* no detailed mention of them is necessary.† According to Hermann, nitrous oxide destroys the red blood corpuscles. Turnbull, however, has experimentally shown that the corpuscles do not give evidence of any change after inhalation of nitrous oxide. I carefully watched the corpuscles in the web of a frog's foot, while the frog was in a bell-jar of nitrous oxide, and was able to observe not only the phenomena of the circulation under these conditions, but also to satisfy myself that no breaking up of corpuscles was evident. The actual changes in the gases of the blood under nitrous oxide were examined by Dr. Thomas Oliver and Mr. F. C. Garrett, who, however, like other observers, do not seem to have been sufficiently careful to obtain an analysis of blood when charged with nitrous oxide, but yet not so deoxygenated as to be practically asphyxial blood containing nitrous oxide. Their results are :—

(Normal Dog).	Before Inhalation.‡	After.
Carbonic Dioxide ...	34·3 ...	15·66
Oxygen	22 ...	3·49
Nitrogen	1·8 ...	11·23
Nitrous Oxide ...	— ...	22·49.

The effect of shaking arterial blood with nitrous oxide gas is to darken it, showing that nitrous oxide gas is able to displace oxygen. But whatever union does take place is very unstable, as blood parts at once with its nitrous oxide when left in free contact with oxygen or air.

* The views I have expressed, and the experiments upon which they are based, are to be found in two papers of mine on the "Physiological Action of Nitrous Oxide Gas." *Transactions of the Odontological Society*, vols. xviii. and xix.

† *British Medical Journal*, November 21, 1897.

‡ Pflüger, see *Lancet*, Sept. 23, 1893, p. 683, for Dr. Oliver's conclusions.

Under nitrous oxide, the respiration becomes slowed and shallow, and, if the gas be pushed, a complete cessation of respiratory movements eventually takes place. The amount of tissue change occurring in nitrous oxide narcosis is lessened, and so the quantity of carbonic dioxide which the lungs give off is diminished. Subsequently to the administration, the exhalation of carbonic dioxide is increased. The heart beats quietly, fully and regularly under this gas, the pulsations are somewhat slowed in profound anæsthesia. There is, however, but very slight danger to healthy persons of heart failure resulting from inhalation. In animals killed by nitrous oxide gas, the heart goes on beating even after the respirations have quite stopped. It is, therefore, less important to watch the pulse than the respiration. Blood pressure is somewhat increased and markedly so in the brain and cord, the vaso-motor system of different areas being, it would appear, diversely affected. This altered pressure is, however, usually but slight. Dr. George Oliver has made some important observations upon the variations in blood pressure under anæsthetics. By the use of his arteriometer, he found that when nitrous oxide was given alone, if it were pushed to a stage in which asphyxial symptoms began to show themselves, it caused "a slight expansion of the calibre of the artery followed by a reduction either to the normal calibre or to a point or two below it," although, "the drop below the normal need not take place," *i.e.*, when a simple nitrous oxide effect takes place. When oxygen is given with the nitrous oxide no reduction of the normal calibre takes place.

In some observations I made upon this subject, I found that while asphyxia caused diminution of the bulk of the brain and cord, nitrous oxide produces so great an enlargement as to force out the cerebro-spinal fluid. There can

be no doubt these changes are vaso-motor in origin, and explain many of the nervous phenomena elicited in persons narcotised by nitrous oxide.

The senses of a person passing under nitrous oxide are at first rendered somewhat more acute, after which follows a condition of analgesia. During the first degree of unconsciousness, a loose tooth may be extracted without pain, although the patient has a vague idea that something is being done. A few seconds later, and the individual is profoundly unconscious and insensitive to all his external surroundings. Irregular discharges of nervous energy frequently show themselves at this stage in jactitations of the arms and legs. These movements are probably due to the deprivation of oxygen, as the admixture of air or oxygen before they develop effectually prevents their appearance. If the gas continues to be respired and oxygen is excluded, the limbs become rigid, the rigidity being every second or two broken by a sudden contraction of the flexors. Rhythmic tremors of hands and arms are occasionally elicited. More rarely the whole body of the patient arches backward like a bow (opisthotonos), jerking him out of the chair. Mr. Clover recorded a case of an adult who jerked himself completely out of the chair in this way. This condition is especially liable to occur in children. The muscles soon relax and remain flaccid. The degree of rigidity and the amount of jactitation vary in different cases; children show jactitation early, and the movements of the limbs are more marked in them than in adults. The superficial reflexes are abolished, that of the patella tendon, however, persists; and in many cases ankle clonus is developed under nitrous oxide.* The pupil usually undergoes wide dilatation when complete

* For further particulars on this point see a paper by the author on "Ankle Clonus under Nitrous Oxide," *British Medical Journal*, Sep. 24, 1887.

anæsthesia is attained, however, this phenomenon is not absolutely constant and cannot be taken as an indication of danger. When given with air or oxygen no muscular movements show themselves. Mixtures of nitrous oxide and oxygen, when given through long periods as in surgical operations, are apt to induce a stiffness, sometimes amounting to rigidity, which constitutes an objection to their use for long operations in general surgery. It has been shown that the elimination of carbonic dioxide is lessened during the inhalation of nitrous oxide, so that it is only reasonable to expect some effects of accumulation of this gas in the blood and tissues. As Mr. Paterson has pointed out it is probable that "a process of internal asphyxia" may occur.*

During the condition of hyperæsthesia which precedes anæsthesia, the subject is often affected by hallucinations, frequently of an erotic nature, and the impressions then received remain firmly imprinted upon the brain. The difficulty of convincing persons that such impressions are not realities should lead every administrator to secure independent evidence of his actions while his patient is unconscious. The bladder and even the rectum may be involuntarily emptied under nitrous oxide, especially in nervous persons, or if the anæsthetic is pushed, and hence it is always wiser to allow patients to pass urine before taking this anæsthetic. As a rule, the alimentary tract is unaffected by nitrous oxide, and nausea, vomiting, and bilious derangement, rarely occur after its administration. However, some persons through nervousness swallow the gas, and this causing distention of the stomach may give rise to a reflex vomiting. In view of the possible occurrence of this trouble, it is well for patients to abstain from food immediately before taking nitrous oxide gas.

* *West London Medical Journal*, 1899, p. 204.

Later effects, which are said in some instances to ensue from the gas, are various functional derangements of the nervous system, tinnitus aurium, headache, and amaurosis, but these conditions occur only with the most exceptional rarity.

Laffont arguing from a somewhat limited number of cases, considers that the effects of nitrous oxide is to produce untoward complication (1) in pregnancy, (2) at the menstrual epoch, (3) in persons subject to nervous disorders, (4) in diabetes, on account of the prejudicial effects of deprivation of oxygen in these conditions. As will be pointed out later, his contentions are fully met if we adopt the correct method of giving nitrous oxide, which is to avoid any asphyxial complications.

It may be said generally that our present knowledge of the physiological action of nitrous oxide goes to show that that agent has not any deleterious action in itself. It is a heart stimulant and is free from any irritant action on the lungs, it does not interfere with the functions of digestion or of the kidneys, but if given without sufficient care or knowledge bad results may accrue, through the supervention of symptoms due wholly and solely to the accompanying but unnecessary deoxygenation of the blood and tissues.

Duration of anæsthesia.—The induction period of anæsthesia by nitrous oxide varies, but is about 55 seconds. The duration of anæsthesia is for anæmic persons and children, about 30 seconds; for adults, 40 to 45 seconds. When given with air or oxygen, the duration of workable anæsthesia is longer, as the operator can depend upon immobility throughout the whole period of unconsciousness.

The greater the amount of gas inhaled, the longer the period of anæsthesia, so that provided the patient is

respiring freely all the time, a longer period of induction leads to a longer anæsthesia. Persons with a large vital capacity take most; children, feeble and anæmic people, least; these last come rapidly under the influence of the anæsthetic, and as rapidly resume consciousness. Such people are good subjects for air or oxygen combined with nitrous oxide, as it allows them to inhale sufficient of the anæsthetic to render their blood saturated to the required extent for an effectual anæsthesia.

Choice of Method of Giving Nitrous Oxide for Various Operations.

In very brief operations occupying less than half a minute, nitrous oxide may be given by mouth inhalation. When the patient is weakly, anæmic, cyanosed, or congested in appearance, or is a child, it is better to employ mixtures of nitrous oxide with air, or oxygen. These mixtures are also better for operations requiring more time, as usually an additional ten seconds or so of available anæsthesia for operating is thus obtained. In longer dental operations the nasal method gives as much time—ten or fifteen minutes in favourable cases—as is usually needed. The alternative methods for these prolonged operations are nitrous oxide followed by ether; chloride of ethyl by itself, or given with nitrous oxide. Nitrous oxide, with air or oxygen, can be given for major operations, provided they are not upon the mouth or naso-pharynx. Mr. Herbert Paterson* has recorded a case lasting two hours and twenty-seven minutes, employing 210 gallons of nitrous oxide, and others of some length. Mr. Bird has employed

* *Trans. Soc. Anæsth.* vol. v., p. 153, 1903, also *West London Medical Journal*, 1899, pp. 202-213.

nitrous oxide during the performance of an ovariotomy, and others have used the method for prolonged cases. I have on many occasions obtained an anæsthesia of half an hour, but personally I regard the plan as less valuable in long, than in brief operations. There is rigidity, light anæsthesia, liability to reflex movements, and often some sequelæ such as headache and vomiting.

Dental Surgery.

Nitrous oxide alone, or combined, is the safest and probably the best anæsthetic for this branch of surgery. When nitrous oxide is used alone, and pushed to the point of stertor and jactitation, two or three teeth may be extracted at one sitting, and expertness in operating may, in some cases, enable many more to be removed. Abnormality of the teeth or mouth may render extraction so difficult, as to prevent the successful removal of one tooth at a sitting, and in all instances it is better not to promise the extraction of several teeth, unless the case be manifestly an easy one. The operation should never be continued when the patient is becoming conscious, otherwise he will complain that he perceived the removal of every tooth; to obviate such mishaps, an operator would do wisely to place himself in the hands of his anæsthetist, who will generally be better able to judge what may be done with impunity. Unless some special reason exist for desiring to extract several teeth at one sitting, it is advisable to let the patient attend twice or thrice, rather than to subject him to more than one administration on the same day. Extracting a number of teeth simultaneously produces more or less severe shock, and should, therefore, when possible, be avoided. When it is neces-

sary to perform an extensive operation at one sitting, one of the plans suggested below (p. 87) may be adopted.

Nitrous oxide may be given:—

1. By itself.
   a. By inhalation from a bag through a valved face-piece.
   b. By the "open method" (Flux).
   c. By mouth injection (Coxon).
   d. By nasal methods of Paterson or of Hilliard.
2. With some admixture with air.
3. With oxygen.
4. Combined with ether.
5. Combined with chloride of ethyl.

The Administration of Nitrous Oxide Gas.

It will be necessary to gain an accurate knowledge of the apparatus required to produce anæsthesia by the above methods, and a description of these, as well as various necessary adjuncts, is here given.

Apparatus Required.

(*a*) **Nitrous oxide alone.**—The apparatus figured below is a simple and convenient one. Its main peculiarities are that (1) it is provided with an efficient "silencer" (*K*) which ensures absolute quietude, (2) it is adapted for gas only, and so offers no temptation to the administrator to give "only a whiff of ether," (3) it possesses a special contrivance to filter the air, and, if necessary, to impregnate the gas with aromatic or other vapours. It consists

of the usual tripod (*A*), used because it is so portable and compact; this supports a steel cylinder containing fifty

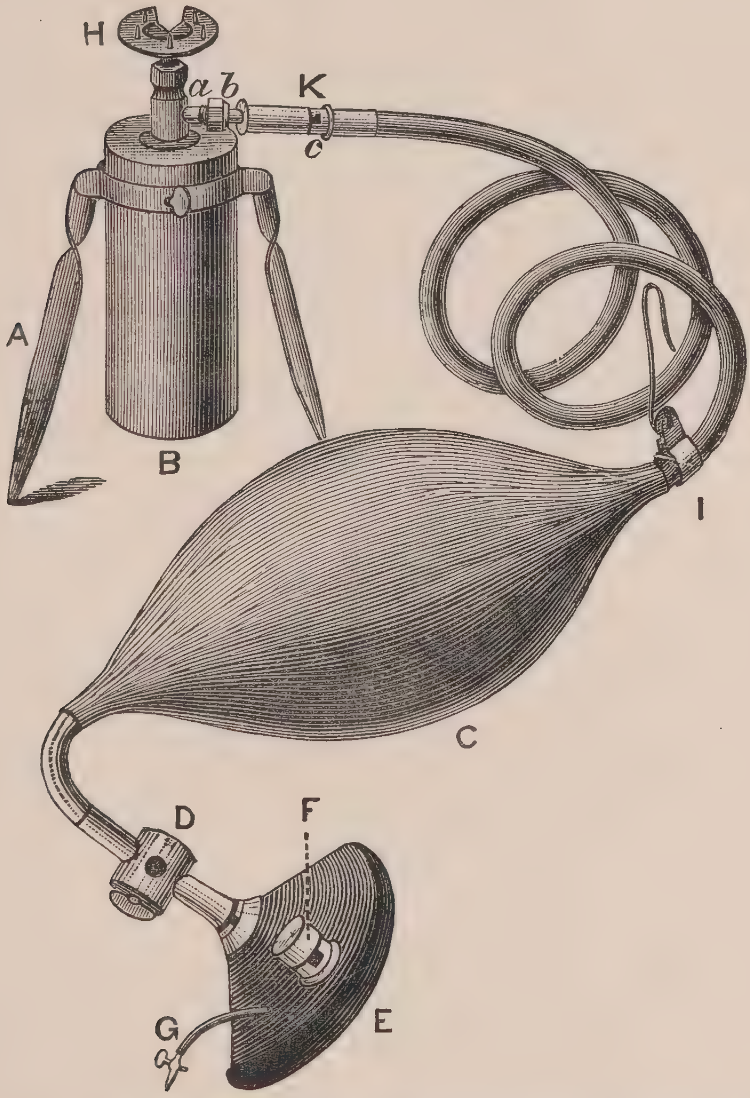


FIG. 1.—Dr. Dudley Buxton's Apparatus for giving nitrous oxide. (*A*) Tripod. (*B*) Steel bottle containing liquefied nitrous oxide. (*C*) India-rubber bag. (*D*) Chamber containing sponge, cotton-wool, &c. (*E*) Face-piece fitted with (*F*) cap expiration valve. (*G*) Tube for inflating the air cushion. (*I*) Hook attaching tube to administrator's button hole. (*K*) Silencer.

gallons of compressed nitrous oxide (*B*). If the use of a horizontal cylinder is preferred, it can, of course, replace

the vertical one figured. To the outlet pipe (*a*) of this bottle is fixed the silencer (*K*), which checks all the hissing and spluttering of gas, and from this a mohair tube of large calibre conducts the gas into an ordinary Cattlin's bag (*C*). Another tube is attached to this, which communicates with a chamber made in metal, and opened or closed by a valve, permitting either air or nitrous oxide gas to enter. In this chamber (*D*) are placed morsels of fine honeycombed sponge, or teased-out medicated cotton-wool. These substances can be moistened with lavender water, eau de Cologne, or with sal volatile, or liq. ammoniæ dil.—if a stimulating action is needed. When it is wished, chloride of ethyl can be given in succession to nitrous oxide, by introducing the required amount of the former into the chamber (*D*). The ordinary Clover's face-piece (*E*) is attached by a bent metal tube, and provided with an efficient expiration valve of peculiar construction (*F*).

In cases when the breath or buccal exhalations are likely to be infective,* as, for example, in phthisis, syphilis, quinsy, &c., the use of cotton-wool steeped in a germicide, such as terebene, is desirable. The cotton-wool is a perfect air filter, and so prevents all infection of the Cattlin's bag and obviates any fear there might be of infecting the next patient. A few drops of eau de Cologne on the sponge will often help nervous children and in their case the "silencer" proves of great value.

The reversible bag of Mr. Vernon Knowles of Reading, is also a valuable safeguard. It can be turned inside out

* The danger of infection was pointed out some time ago by Mr. Lloyd, in the *Journal of the British Dental Association*, and he recommended that a fresh Cattlin's bag made of very fine india-rubber or paper should be used and destroyed after each case. This somewhat expensive precaution is rendered unnecessary by my simple contrivance. See *Lancet*, May 28, 1887, *idem*, April 10, 1897.

after each inhalation and the rubber thoroughly cleansed. It is easily fitted to any apparatus which may be used.

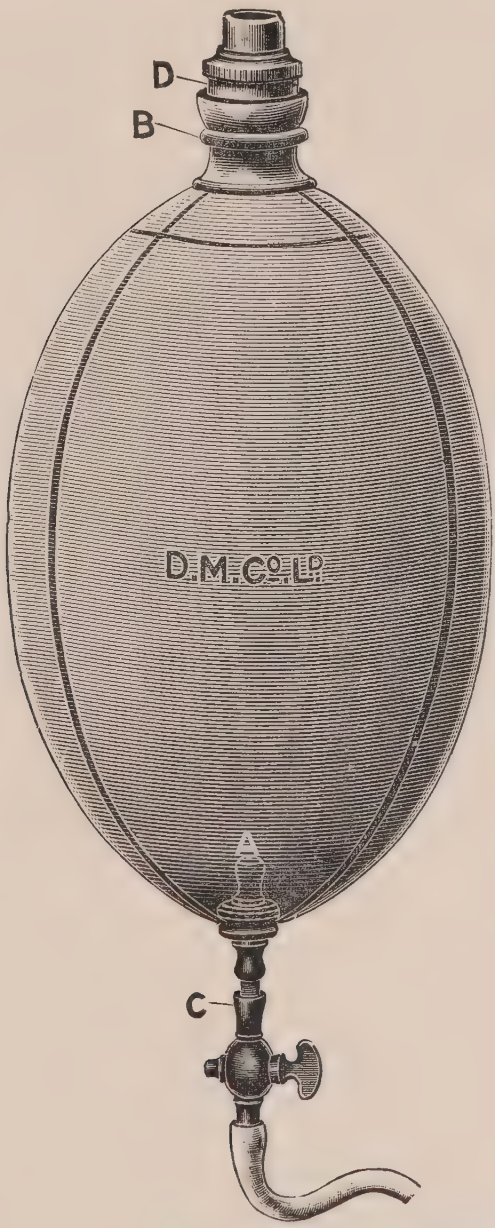


FIG. 2.—Mr. Vernon Knowles' Reversible Bag.

Dr. Hewitt* has designed an useful inhaler which is figured below. The bag has a capacity of from 2 to 2½

* See "Anæsthetics and their Administration," 1901, p. 211. Macmillan.

gallons, and is placed close to the face-piece so that its movements are readily seen, and the patient may experience no difficulty even during the most vigorous inspiration. The valved stopcock connects the gas bag with the face-piece, it contains two thin india-rubber valves which are thrown into action by rotating the tap at the end of the fitting. The handle opens the gas way and when turned so that the slot which it controls is open, the patient breathes air easily enough. The tap and the handle in this manner control the action of the valves

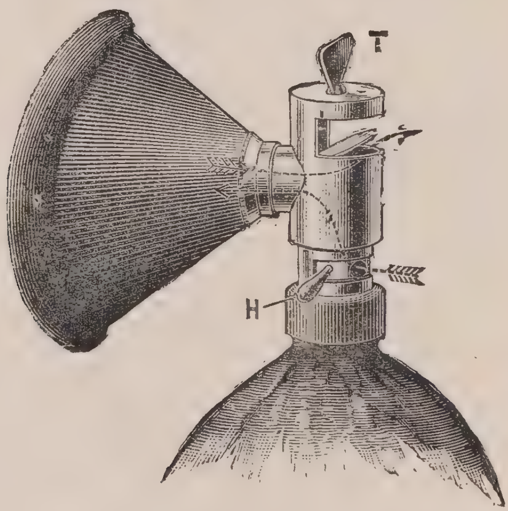


FIG. 3.—Face-piece, stopcock, and gas bag for the administration of nitrous oxide gas only. (Dr. Hewitt's apparatus).

so that air or gas can be breathed through the valves or backwards and forwards. In the last case the bag is converted into "a supplemental bag."

Nitrous oxide cylinders are supplied of sizes to produce 100, 50 or 25 gallons of the gas. It is wise to have two cylinders yoked together to avoid inconvenience should the nitrous oxide fail before anæsthesia is complete. The amount of anæsthetic left in a cylinder can readily be ascertained by weighing, as the weight of the cylinder full

or empty is a known quantity. The exit valve should be perfectly closed after the operation. This can be tested by smearing water over the end of the tube, if gas is escaping the water rises in a bubble.

Subsidiary Apparatus.

Gags.—Various forms are in use, the one made for me has special advantages from the facility it offers for rapid removal and replacement. It consists in replacing the screw-fixing arrangement by a ratchet as is seen in the figure.

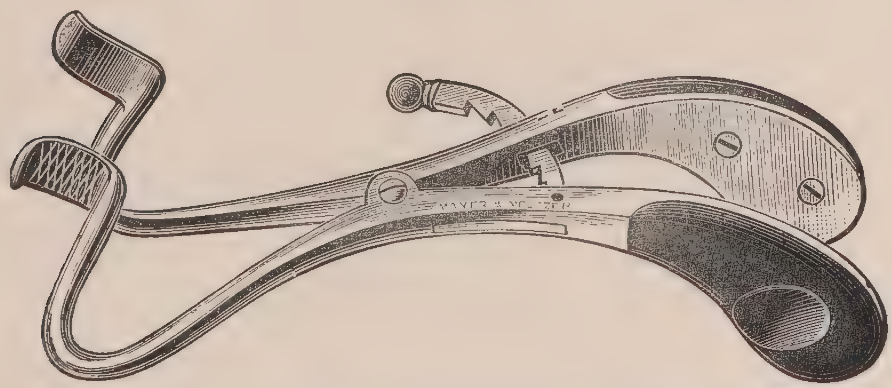


Fig. 4.—Gag fitted with ratchet arrangement. (Mayer and Meltzer).

By putting the finger upon the free end of the ratchet and pressing it backwards as one does a trigger, the ratchet is released and the gag closes. To open it, it is only necessary to press the handles together and the ratchet will automatically gear and prevent closing of the mouth. The ratchet arrangement can be used with long or short handles, personally I prefer the latter. With long handles such powerful leverage is obtained that teeth may be easily forced out of their sockets or snapped off if they are at all brittle.

A very convenient gag has been devised by my friend Mr. Gowan of Great Stanmore, which combines the advantages of a sure gag and a mouth opener in cases in which the teeth are sufficiently apart to allow its insertion. It acts by turning the millhead from left to right, and fixes itself without requiring any screw. This gag is of value in cases of partial trismus.

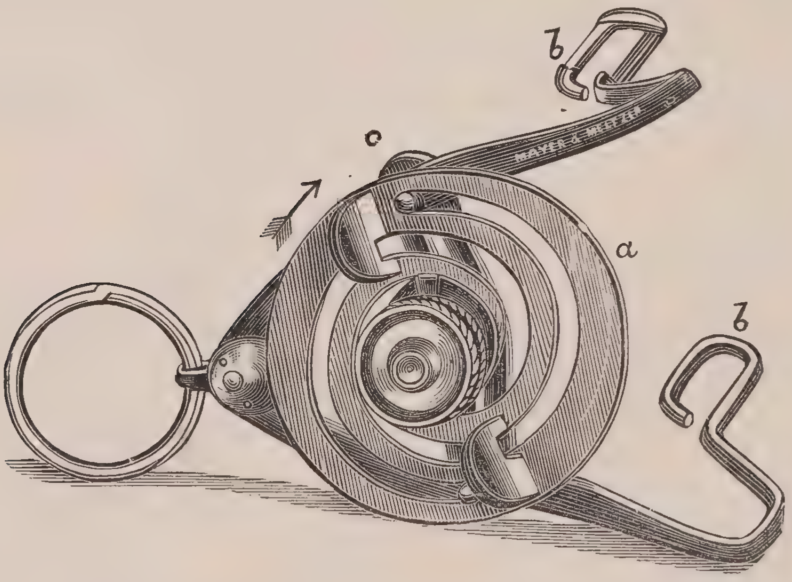


FIG. 5.—Gowan's Gag. By revolving the disc *a* to the right or left the gag is opened or closed. The disc being eccentric, no screw is required for adjusting the gag.

Of mouth dilators, or more accurately openers, Heister's, figured below, is the best. It possesses enormous power, so it must be used with care. Its employment is indicated in cases of severe trismus, partial ankylosis, &c. The blades may be inserted either in a gap caused by the previous extraction of a tooth, and if possible between the molars. If placed between incisors the risk is run of forcing these teeth out of their sockets. Various mouth

openers made of wood or metal, tapering so as to act as a wedge are in use, but need no special mention.

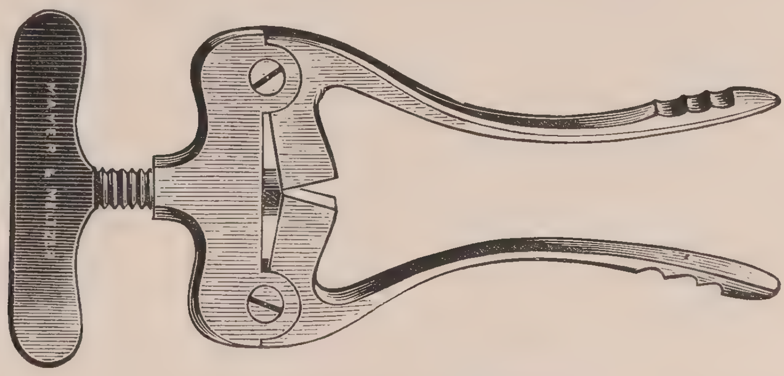


FIG. 6.—Mouth opener (Heister's).

Dental props.—Mr. Clover employed those made of hard wood, but, although very convenient and not liable to slip, they are apt to get chipped and split.

The cleanest and nicest I know are those figured below and made of vulcanite. The shank is strengthened by a metal tube about which the hard vulcanite is placed. The ends are ridged and grooved to prevent slipping.

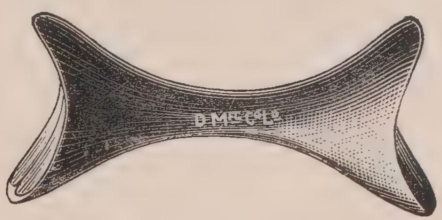


FIG. 7.—Vulcanite mouth prop.

The mouth prop spoken highly of by Mr. A. S. Underwood and figured below is also useful. It has a soft pad at either extremity (fig. 8).

FIG. 8.

Although spring and mechanical props are objectionable upon the general ground of their liability to get out of order or to break, yet some kinds are useful, and I subjoin illustrations of some of the best.

Dr. Hewitt's gags (fig. 9) are serviceable. They are made of metal, shaped to fit between the upper and lower teeth, and have removable indiarubber caps on their extremities.

A central prop, fixing upon the anterior teeth with a rotating arm, permits of operations upon one or other

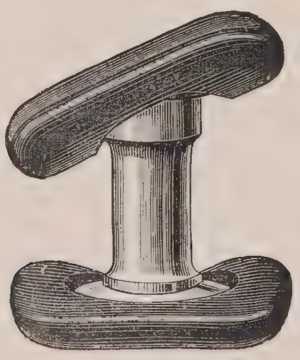


FIG. 9.—Dr. Hewitt's gag.

side of the mouth according to the necessities of the case. A very convenient form is figured below (fig. 10).

It possesses an easily working screw, which permits of very nice adjustment. The plates should rest upon more than one tooth in each jaw.

No mouth prop or cork should be placed in the mouth without being first securely tied to a counterpoise which hangs out of the mouth, and prevents the prop becoming wedged in the larynx or œsophagus in the event of its slipping. The few minutes spent in carefully adjusting the prop between the teeth should not be grudged, as the after success of the operation depends largely upon the security obtained by this manœuvre. It should be adopted

as a general rule, when possible, that the dental prop be placed not further forward than the bicuspids.

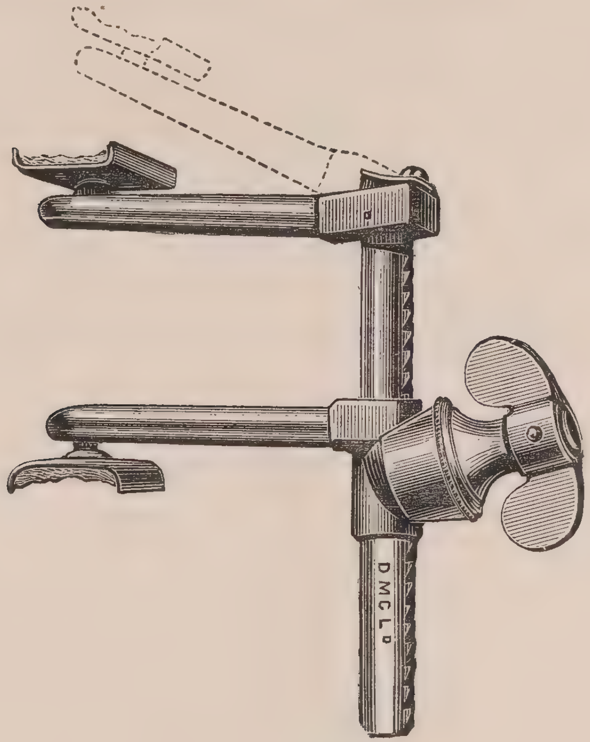


FIG. 10.—Weller's gag.

The mouth spoon (fig. 11), made for me by Messrs. Ash, is safer than Mr. T. S. Carter's original pattern, in which the shank of the spoon is liable to separate from

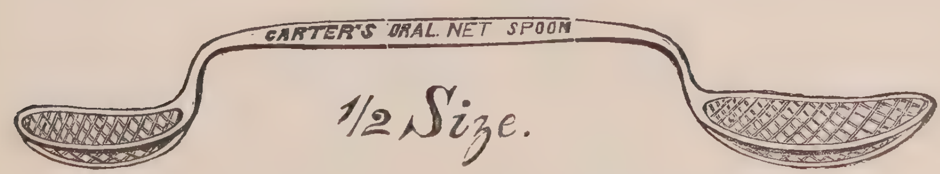


FIG. 11.—Mouth spoon. Dr. Dudley Buxton's pattern.

the bowl with obvious risk. By carrying the shank to the distal end of the bowl as in my pattern, this danger is obviated. The use of the oral spoon is to catch any teeth

or roots which may fall out of the forceps. Lower bicuspids are especially apt to spring out of the beaks of the tooth forceps. The spoon is held below the seat of opera-

FIG. 12.

tion, care being taken not to allow it to get in the way of the operator.

The **tongue forceps** (fig. 12) figured above needs no

special description. Some persons prefer to use an instrument which pierces the tongue, as the punctured wound is believed to heal better than the crushed surface of the tongue caused by the usual form of forceps (fig. 13).

FIG. 13.

A **tracheotomy case** should always be at hand when an anæsthetic is to be administered.

Administration of nitrous oxide in dental operations.—The posture of the patient is a matter of some importance. It is essential that he should be so placed that he is at perfect rest, his muscles relaxed and his breathing and circulation quite unimpeded. To achieve this he is seated in a chair, his body slightly extended on his pelvis, the legs hanging freely and not pressed against the foot-piece. The head should now be in a line with the trunk; any marked degree of flexion or extension, not only causes discomfort, but actually interferes with normal respiration. If the exigencies of the operation require any deviation from the natural pose of the head upon the shoulders, it is best for the anæsthetist to hold the head in the required position *after* the patient has become unconscious, and to restore it to its normal position as soon as possible. Thick necked and stout persons should be most sedulously guarded against malposition, and the effects of pressure about the heart or abdomen. Ladies suffering from slight goitre often disguise the deformity by a lace necktie. It is always wise in view of this to have such neckties undone, that the anæsthetist may at once see whether any cervical swelling exists.*

The apparatus should be tried, and if the gas enters the bag freely and the valves are in good working order the dental prop may be placed in position. It must be carefully fixed in the opposite side of the mouth to that upon which the operation is to take place, and a glance cast round for artificial dentures, or an obturator, which

* A case in my practice emphasizes this point. The patient was obviously a little breathless on entering the chair, and to my question said she "suffered with her heart." The tachycardia suggested goitre, which was looked for and recognised, and measures taken to meet the exigencies of the case. The dental surgeon remarked to me afterwards that a death under nitrous oxide had occurred in his hospital, the patient being affected with goitre.

if present must be removed. Weak or broken down teeth should be noted and avoided in fixing the dental prop, and in the subsequent use of a gag. The administrator usually stands to the left of the chair, having the stand with the cylinders of nitrous oxide to his right and a little behind him. The gas bag should hang freely down to the left of the patient's chest. The patient is now to be reassured by a few cheering words, and directed to breathe naturally. It is well to allow a nervous subject to take several very deep inspirations before applying the face-piece, as these clear the lungs and divert the attention from a supposed horror of "taking gas." The Cattlin bag is partly filled by turning the toothed foot-piece under the foot from right to left. The face-piece is then lightly applied to the patient's face, and retained by just sufficient pressure to prevent the escape of the nitrous oxide or the entrance of air around the air cushion. In a second or two, the patient becomes accustomed to the face-piece, and the administrator is able to learn that the valves act properly. At the instant of inspiration the stopcock is turned so that the patient inhales the nitrous oxide from the bag. During the administration this is kept nearly full of gas, by rotating the foot-piece from right to left. It is well to open the ingress way of gas during inspiration and close it during expiration.

After the first fifteen or twenty seconds, that is, after the lungs are presumably filled with nitrous oxide, and when gas is gaining tension in the blood, slight duskiness of the skin appears, the ears and finger tips darken, consciousness, however, is usually present for ten or fifteen seconds longer. In half a minute the patient's power of receiving impressions and reasoning upon them is greatly interfered with, and soon all consciousness is lost. At

this stage, incautious acts, such as touching the conjunctiva, making loud noises, or roughly handling the patient, may lead to his completely regaining consciousness. In about forty-five seconds after the application of the face-piece, the pupils will usually dilate, the eyes becoming dull and expressionless, while squinting may occur. The conjunctival reflex will persist, and if the face-piece be removed now, the return to consciousness will be rapid. There is at this stage, as a rule, time for the extraction of one tooth, if fairly loose. When the inhalation is not checked at this time, further signs of deeper narcosis appear. The breathing grows stertorous,* muscular movements of the hands and feet supervene, and the conjunctival reflex becomes sluggish, or disappears. The patient is now ready for operation, and it is not wise to attempt to push nitrous oxide beyond this point.

In giving nitrous oxide to children, the face-piece should be removed with the very first sign of jactitation, otherwise their small bodies become so convulsed, that it is difficult to keep them still for operation, and valuable time is lost in the attempt to place them in a convenient position. The jactitation may be prevented by the use of oxygen, or more simply by admitting a breath of air by opening the air valve while the nitrous oxide is shut off, or by removing the face-piece. This should be done when the patient is almost ready for operation, and usually the muscular quivering of the orbicularis palpebrarum gives the warning that jactitation is about to

* Laryngeal stertor must be carefully discriminated from "snoring." Patients with a thick pendulous uvula, or enlarged tonsils or post-nasal adenoids, begin to snore a few seconds after the commencement of inhalation, also persons with loose baggy cheeks make a stertorous sound, but false stertor should be ignored. The true stertor, caused by vibration of the arytæno-epiglottidean folds, only comes on after forty or fifty seconds of inhalation, and is more musical in character.

commence. After one or two inspirations of air, the face-piece is reapplied, and the patient allowed to take several inspirations of the gas.

It is important to be able to recognise the signs of returning consciousness, so as to know when to desist from further operative measures, and this can usually be done with certainty. In the first place, the normal colour of the face returns, the lips change from their ashen hue to a natural crimson. The eyes recover their look of intelligence. The patient commonly moves a limb, or utters a cry, though not one which implies consciousness; restless movements of the body often occur. Children, also, are very liable to cry out although quite unconscious, and it is well to warn friends of this, otherwise they imagine the anæsthesia has failed.

It is claimed by some authorities, that rebreathing the gas towards the end of the inhalation produces a more prolonged period of anæsthesia, and is in no sense prejudicial. To effect this rebreathing, the expiration valve is closed, and the bag becomes a "supplemental bag." It is difficult, even on theoretical grounds, to understand why the rebreathing of nitrous oxide should produce a prolonged effect, even if we admit that the supposed addition of carbonic dioxide acts concurrently with the anæsthetic. As has been pointed out, the amount of this gas given off during the inhalation is lessened, so that the quantity acting during the few seconds occupied by the rebreathing would be extremely small. It is the devitalisation of rebreathed air, rather than its impurities, as has been shown by Sir Benjamin Ward Richardson, which renders it deleterious. There is always debris from the lung tissue in rebreathed air, which in many, if not in all cases, it can hardly be desirable to breathe.

Occasionally the induction of anæsthesia by nitrous

oxide is described in "degrees" of narcosis, but the delimitation is so slight and empirical, that I have not been satisfied that such a proceeding is of any real value.

After Effects.

These are, as a rule, conspicuous by their absence; hysterical women may laugh and cry, and work themselves up to a pitch of excitement, which sympathetic friends attribute to "the gas"; persons exhausted by fasting and vigil or disease may become faint; epileptics occasionally have a fit during the exhibition of the gas, or immediately afterwards. Vomiting is rare after nitrous oxide gas, although such a complication may occur with children, or if the anæsthetic be given immediately after a meal. Pereira states that in one case loss of taste followed it, and I have met with a patient by whom anosmia was complained of for some days subsequently to the extraction of a tooth under nitrous oxide. Among a few persons of peculiar organisation, certain nervous symptoms have been known to follow, as for instance, severe headache and general malaise. Sleeplessness for a few nights occasionally occurs; I have met with it in a young delicate girl, who evinced no other ill-effect after inhaling nitrous oxide. Transient albuminuria has also followed it. It is alleged that glycosuria, and even diabetes have been caused by the inhalation of nitrous oxide, personally, I have never known of any such complications. These symptoms, rare after a single administration, are less infrequent when this anæsthetic is repeated twice at one sitting, hence it is better, when possible, to avoid the repetition. The graver dangers and deaths which have occurred under this anæsthetic are considered below (pp. 91 *et seq.*).

(*b*) **Open method.**—Certain persons and children are greatly alarmed by having a face-piece held over their nose and mouth. To obviate the necessity for this, Dr. Flux has devised an ingenious plan for giving nitrous oxide by an open inhaler.* His procedure is as follows:—Gas is poured into the upper open part of the inhaler through the stopcock leading from a gas-bag connected in the usual

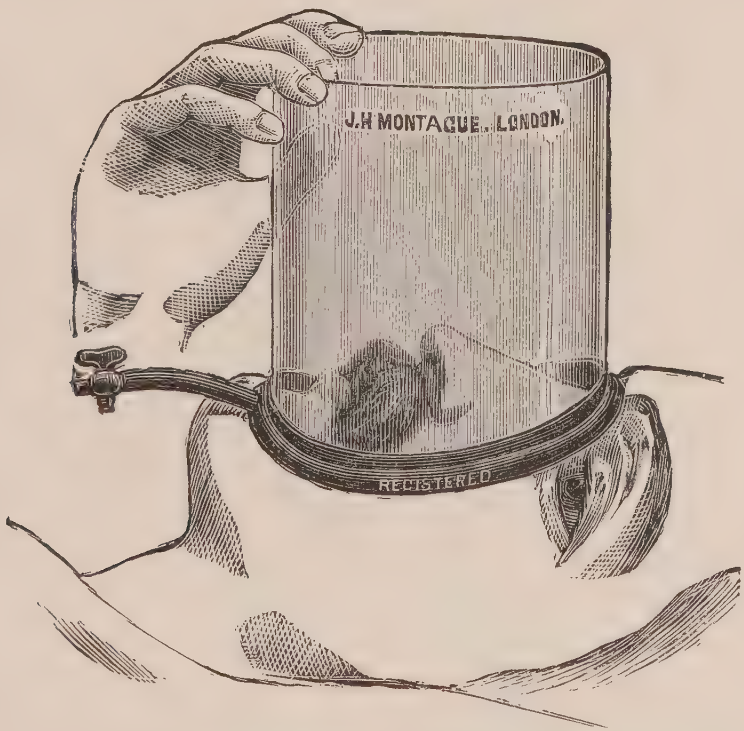


FIG. 14.—Flux's open method. Patient in recumbent position.

manner to the source of supply. The nitrous oxide gas is only allowed to flow during inspiration, and owing to its great weight falls directly into the face-piece. The movements of respiration, and the warmth of the expired vapour, tend to empty the inhaler, to prevent stagnation of its contents, and to favour the mixing of gas with air.

* See Dr. Flux's paper in *Transactions of the Society of Anæsthetists*, vol. ii., p. 140.

Violent injection of the gas into the face-piece is undesirable, especially in the case of small persons or shallow breathers, as the air by this means may be completely driven out before diffusion of the gas has had time to occur.

The inhaler is open at the top and the edges must fit the face accurately in order to prevent any escape of gas below the level of the nose and mouth. With very young

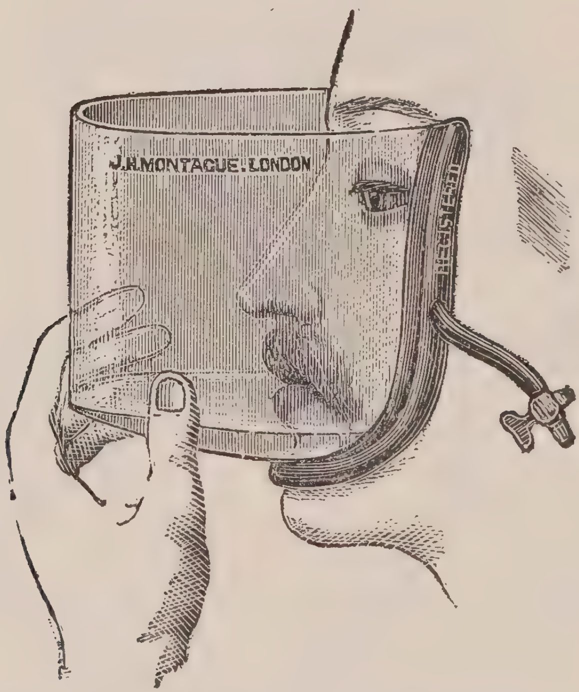


FIG. 15.—Flux's open method. Patient in sitting posture.

children it is often convenient to use simply a folded napkin instead of a formal face-piece. In other cases, where it is inconvenient to employ a specially constructed open inhaler, an ordinary face-piece kept open by being tilted back from the face can be used. The results obtained by Dr. Flux's method are good, the most striking features being the tranquillity of the patient, the absence of cyanosis and of any sense of oppression. The amount of gas in-

haled by the patient does not appear to exceed that with other methods, but occasionally in unaccustomed hands, or when the supply of gas is not under easy control the amount *used* is in excess of what is *required.* I have adopted Dr. Flux's plan frequently, and although recognising its merits in simple cases, I think it is better, as a rule, to commence the inhalation by the open inhaler and conclude with the usual closed mask. In this way one avoids the initial fright and yet ensures a deeper narcosis and better anæsthesia than can be relied upon when the open mask is used throughout the administration.

Prolonged administration of nitrous oxide.—For cases where the operator requires an appreciably longer period for his work one or other of the following methods may be employed.

(*c*) **By mouth-tube.**—Mr. S. A. Coxon's method * is as follows :—The patient is rendered unconscious by the use of the usual apparatus. The face-piece is then removed and a bent tube of large calibre connected with the nitrous oxide supply is introduced into the mouth so that its free end is a short distance from the uvula. It is most conveniently passed behind the dental prop. A steady stream of nitrous oxide, which Mr. Coxon recommends should be warmed, is maintained until the operation is completed.

(*d*) **Administration by nasal methods.**—The use of nasal tubes and catheters for maintaining nitrous oxide anæsthesia was suggested by Mr. Clover, but he and others found it possessed many drawbacks. Mr. Harvey Hilliard† has more recently modified the plan, and devised

* *Transactions of the Society of Anæsthetists*, vol. i., p. 123.

† *Ibid.*, vol. i., p. 170. See also *Dental Record*, April 1, 1898, p. 147.

a new apparatus which in his hands appears to be successful. Mr. Alfred Coleman's plan of giving nitrous oxide by the use of a nasal cap has been improved by the apparatus devised by Mr. Herbert Paterson.

Mr. Paterson's apparatus * is figured below. The nasal cap is carefully adjusted, the bag filled with nitrous oxide and the stopcock turned. The patient is requested to inspire through the nose and expire through the mouth. Ordinarily intelligent persons will soon learn to do this, but to assist them the celluloid face-piece is placed over the mouth after the insertion of the dental prop. The celluloid mask has an expiry valve but admits no air. In about half a minute stertor is heard, the celluloid mask removed, and the operation commenced. Nitrous oxide is allowed to flow, unless cyanosis, or other sign of deepening of the narcosis to an undesirable degree appears. If such occur the stopcock is turned and the nitrous oxide cut off for one or more respirations, to be then again supplied and anæsthesia maintained as long as the operation renders it necessary. The method is valuable for operations at the back of the mouth and for lower teeth, as in practice, especially in persons with a short upper lip, the nasal cap gets in the way when front teeth in the upper jaw are being extracted. The cyanosis which is very liable to supervene can usually be avoided by using a supply of nitrous oxide, under low pressure, during the induction, or as Mr. Luke † of Edinburgh suggests, by employing a little oxygen concurrently with the nitrous oxide. It is a good plan when prolonged administration of nitrous oxide is employed, to diet the patient beforehand and to make him gargle well before inhaling, as

* See Mr. Paterson's paper in the *West London Medical Journal*, vol. iv., p. 211.

† "Anæsthesia in Dental Surgery," p. 64, 1903.

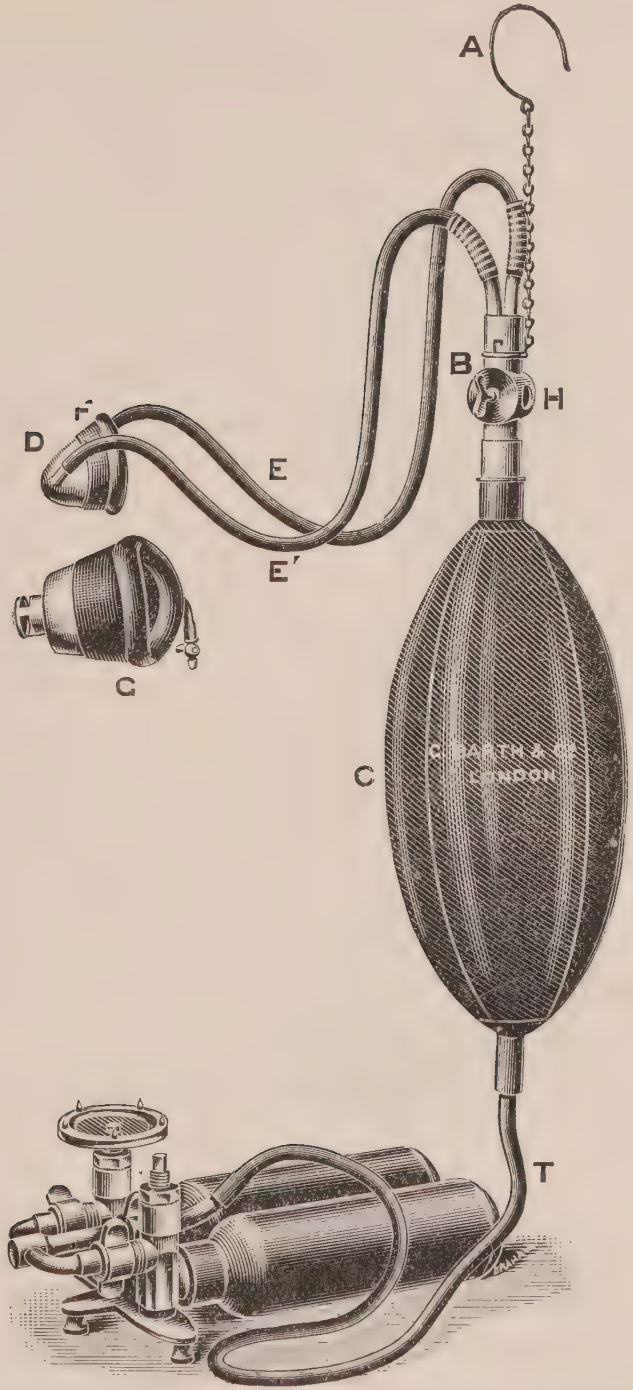


FIG. 16.—Mr. Patterson's apparatus for giving nitrous oxide through the nose. *D*. Nasal cap. *G*. Celluloid mask. *B*. Valve.

mucus collecting in the nasopharynx interferes with anæsthesia and produces cyanosis. My friend Mr. Howard Mummery pointed this out to me, and following his suggestion has certainly facilitated the onset and quiet main-

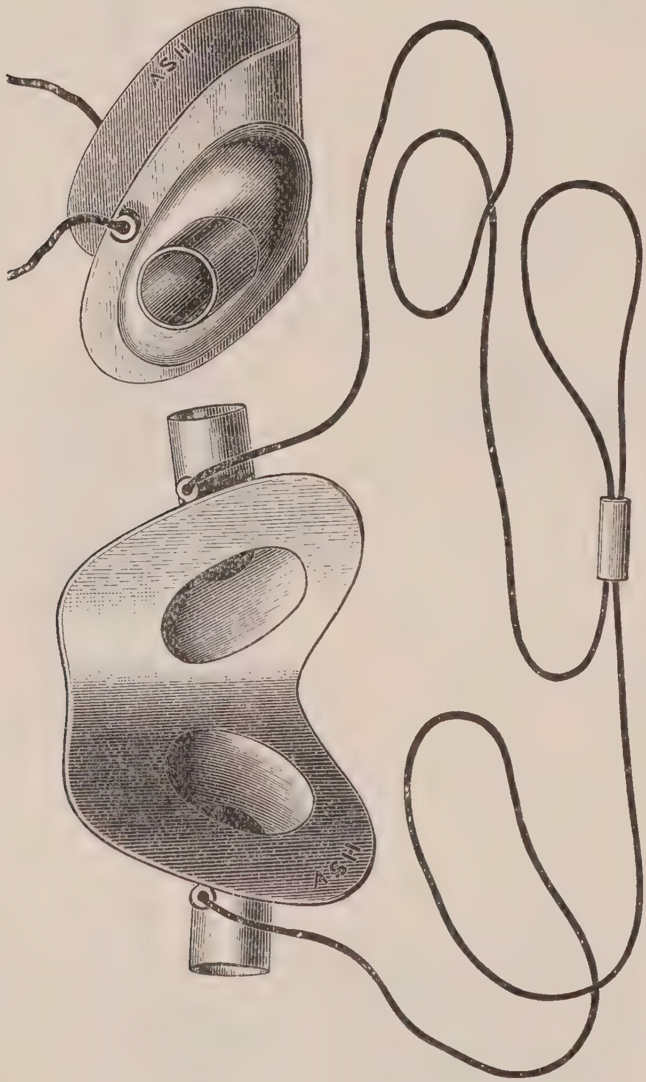


FIG. 17.—Inside and outside views of Mr. Lennox's nasal anæsthetiser.

tenance of anæsthesia. A considerable supply of nitrous oxide must be at hand, as 30 to 40 gallons (Luke) are required for a ten minutes' anæsthesia, although, as Mr. Paterson points out, experience with the use of the method

enables an administrator to lessen very considerably the amount of anæsthetic consumed for each patient. Mr. Lennox of Cambridge has suggested a very simple and efficient apparatus for nasal anæsthetisation. This is figured above. As is shown, the nasal cap fits closely to the nostrils and does not get in the way of the operator; this device is most useful when the patient is short lipped, or when anterior upper teeth have to be removed. Mr. Luke * refers with approval, to a plan of Mr. Nash of Ayr, in which an expiry valve is placed on the nasal cap, and various sizes of nose-pieces to fit different types of faces are used.

Difficulties and Minor Complications under Nitrous Oxide.

Retching and vomiting.—Some persons retch as soon as the mouth is fixed open by placing the dental prop in position, and this may even induce sickness. In most cases this arises from the mouth having been too widely opened, and is corrected by bringing the prop forward and letting the mouth be partially closed. It is necessary occasionally to employ an extremely small prop and open the mouth by means of a gag when the patient is unconscious. In extreme cases, if the patient gargles the throat or has it lightly sprayed with a solution of cocaine (2 %), the trouble can be overcome.

More troublesome patients are those who commence to retch at a point when unconsciousness has occurred but the narcosis is only light. It is usually impossible to push the nitrous oxide inhalation, and one has to be content

* *Op. cit.*, p. 30.

with a brief anæsthesia, and adopt another anæsthetic on the next occasion.

Holding the breath by nervous patients can usually be overcome by tact and a few encouraging words, but I have met with persons who have induced semi-asphyxia and faintness by their persistency. Putting the jaw forward rhythmically will induce an inspiration, and breathing once started will be maintained. Force should never be used except when it is necessary to prevent the patient from hurting himself. Children may be restrained, however, and compelled to inhale provided their parents are willing that a certain amount of firmness should be employed. In every case of breath-holding it is essential that one should ascertain whether any physical reason for it exists, such as spasm of the larynx or faulty position of the patient.

Coughing, sneezing, and "gagging" seldom give trouble except in the stout and plethoric. If there is reason to fear the result of straining, as when the heart is feeble, it is better to give oxygen freely, or failing this, air, and not press the anæsthetic until the complication has passed off. If the condition occurs early and obviously produces great distress, it is better to take off the face-piece and start *de novo* when the patient has got over the attack. "Gagging" is usually due to irritability of the pharyngeal wall and commonly occurs in smokers. In slight degrees it is remedied by pushing the anæsthetic.

Pallor and cyanosis.—Paling in young patients may arise from slight faintness, but must be closely watched, as if it increases, especially when nitrous oxide is being given by itself, it may lead to syncope and require prompt treatment, such as lowering the head. Cyanosis on the other hand is commonly met with among elderly

persons, especially if stout and plethoric. It increases even after the withdrawal of the face-piece, and requires careful treatment. Even with oxygen this condition may supervene, and if in spite of increasing the oxygen it is not removed, the patient should be allowed to come round, as forcing nitrous oxide in these cases is a dangerous practice.

Hæmatemesis and epistaxis.—The former rarely occurs, and when it does must be treated on general medical principles. It is obviously essential to place the patient in a recumbent posture and to turn the head to one side. But like epistaxis a minor degree of hæmatemesis may occur and not be recognised if the administrator has allowed his attention to flag. Epistaxis will seriously interfere with respiration when the head is extended. Slight nose bleeding is not at all uncommon after inhaling nitrous oxide. In either case the administration must be stopped.

Hysteria and excitement.—Occasionally excitement, almost maniacal, occurs after nitrous oxide, while lesser degrees of emotional disturbance are not uncommon. No serious treatment is necessary; judgment and firmness will meet the requirements of the case. The tendency to erotic dreams and hallucinations under these circumstances should be remembered.

Dislocation of the jaw either partial or complex may occur. Its treatment, however, belongs rather to the field of surgery.

Dangers Attending Nitrous Oxide Administration.

Syncope.—Among the graver complications may be noted syncope. While syncope seldom occurs during

nitrous oxide narcosis, it is undoubtedly a possible danger, especially among the neurasthenic and feeble. It may take place before complete narcosis, and is then probably due in part to subjective sensations, such as dread of the impending operation, terror of the anæsthetic, or fear of suffocation. There are reported cases in which syncope has only been observed after removal of the face-piece, while in others, all has apparently gone well until the operation has been commenced, when the condition of the patient suddenly became alarming. Whether death from syncope due wholly and solely to nitrous oxide has ever taken place is doubtful. In the few deaths which have attended its use and have been reported, incomplete anæsthesia has played an important part, while fright and shock have undoubtedly contributed to the causation of the fatal result. When nitrous oxide is given without regard to the avoidance of asphyxial complications it may lead to syncope, due to grave interference with the pulmonary circulation. Persons whose breathing is hampered at the time of taking nitrous oxide incur the gravest danger of syncope, if this gas is incautiously employed. The anæmic are also liable to this danger unless care is taken to avoid undue deprivation of oxygen. Stout persons wearing tightly laced corsets are prone to syncope, and have succumbed to this while under the influence of nitrous oxide, especially if the stomach is distended by a recent meal.

Faintness.—Less severe forms of circulatory failure, however, such as faintness, sometimes supervene, and should be counteracted by placing the patient supine on the ground, chafing the hands, applying smelling salts or aromatic vinegar to the nostrils, and slapping the face and chest with towels wrung out in very cold water. All garments about the waist, chest, and neck, must be

loosened, if this has not been done, as it should have been, before the gas was administered. The inhalation of a few whiffs of nitrite of amyl will often relieve the heart. It is sometimes advised to inject ether under the skin, but the utility of this is doubtful, nor is it likely to be called for in the class of cases above mentioned. A measure which I have practically tested and have reason to estimate very highly is partial or total inversion of the patient. In the movable dental chairs, so commonly used, this can be done even in the case of women without indelicacy or difficulty.

Respiratory difficulties.—In some cases a certain amount of **laryngeal spasm** may occur although it is rare. A case has been reported in which this condition was so severe as to render laryngotomy necessary.* As a rule, drawing forward the tongue using rhythmic traction will relax the spasm. Breathing in some cases becomes very shallow and may stop altogether, but this need not cause alarm unless indeed it should cease for longer than five or six seconds. Then it is well, after seeing that there is no falling back of the tongue or foreign body impeding respiration, to press up the ribs from below by standing in front of the patient, and grasping the chest

* An instructive case is published by Dr. F. Hewitt. A patient, æt. 35, suffered from fixation of the bodies of the vertebræ which precluded all save very slight rotatory and nutatory movements. The neck muscles were unduly rigid and the jaws could be opened only to a fourth of the normal extent. The fixation was the result of rheumatic fever. The gas was taken well and the tooth extracted. It was then remarked that the usual recovery did not occur, the respiration becoming more and more embarrassed "as though some obstructive condition of the air-passages" existed. "The sound made by the last attempt at respiration was to a certain extent suggestive of fluid at the back of the throat." General fixation of the thoracic walls and rigidity of the jaws and muscles of the neck rendered the measures usually adopted, such as artificial respiration, swabbing out the pharynx, &c., impossible; and as inversion failed to restore the patient's respiration, Dr. Hewitt performed laryngotomy which at once relieved the spasm and the patient did well. See "Anæsthetics," 1901, pp. 450 and 451.

with both hands placed about the lower half of the bony thorax. This simple manœuvre will initiate spontaneous respirations, and all will go well. Young children occasionally cease to breathe if the nitrous oxide is pushed to profound narcosis, and compression of the chest becomes necessary. Patients suffering from conditions such as laryngeal stenosis, goitre, enlarged glands and inflammatory swelling of the neck are peculiarly liable to respiratory difficulty under nitrous oxide. As has been pointed out, it is better to avoid this anæsthetic for such cases, and if it is used at all it must be limited in dose, and all asphyxial phenomena carefully watched for and remedied by the use of oxygen, and the upper air-passages must in threatened asphyxia be opened. Even enlarged tonsils, especially when inflamed, may cause serious danger under this anæsthetic. A case in which death followed the administration has been recorded.* I have on a few occasions met with respiratory difficulty which was fortunately only transient, evinced by cyanosis and severe dyspnœa in persons whose only apparent disability consisted in their being plethoric, and having a short thick neck and rigid chest.

Asphyxia caused by foreign bodies.—Vomiting during inhalation of nitrous oxide is uncommon, but may occur and even escape notice. If the vomit is aspirated into the lungs fatal results may follow, especially if the patient has incautiously taken solid food recently. Portions of undigested meat or other solid may, of course, become impacted in the glottis and cause dangerous or fatal results. Impaction in the œsophagus may by pressure produce suffocation. A sponge used to prevent blood entering the larynx has in one case proved fatal. The person who placed the sponge in position appears to have forgotten

* *Transactions of the Society of Anæsthetists*, vol. vi., p. 12.

it, and it was allowed to remain over the glottis occluding the air-passage while artificial respiration was kept up. Among dangers must be mentioned those which are due to the operation rather than to the anæsthetic. Thus, when a prop is placed between the teeth, it should be guarded from slipping back into the windpipe by being tied to another hanging freely outside the mouth, and the props used should be made of some material not liable to crack or break off. The mouth should be cleared of artificial dentures, especially small plates. Accidents have arisen from teeth or portions of teeth being allowed to fall back from the beaks of forceps to the glottis, a deep inspiration then drawing the tooth into the trachea Bicuspid teeth from their shape are very prone to jump out of the beaks of the forceps during extraction. In several recorded cases these teeth have entered the trachea and caused death, either at once or secondarily, by causing abscess of the lung. The tooth forceps have in recorded cases broken, and a fragment become lodged in the bifurcation of the trachea.

The dangers of these casualties are:—(1) immediate, from asphyxia due to laryngeal spasm excited by the foreign body becoming impacted in the larynx; and (2) secondarily from septic pneumonia set up by the foreign body having found its way into a bronchus.

To deal with such cases.—Firstly, as to precautions. All instruments used for the mouth should be carefully examined for flaws, and all gags, props, &c., be secured by fishing gut, or some strong cleanly material, and attached outside the mouth.

In extracting teeth the forceps should after each extraction be wiped quickly *twice* across a napkin, in order to free them from the tooth just removed before the next extraction is attempted. Fragments of teeth should never

be left loose in the mouth, even with the object of gaining time. The use of the mouth spoon (p. 77) will often avoid these serious accidents.

Should there be any fragments detached from the tooth or forceps, &c., which cannot be seen and picked out, the anæsthetist should at once bend the head forward and sweep the finger round the mouth so as to carry any foreign body forward, when it can be seized and removed; in this way it may sometimes be possible to dislodge a foreign body situate at the epiglottis. It should be remembered that the tongue must not be drawn forward, as by so doing the larynx will be left exposed, the epiglottis being dragged from it, also because the patient is thereby induced to take a deep inspiration which facilitates the passage of the foreign body into the air-passages.

If the obstruction cannot be felt, and there are signs of impending asphyxia, inversion should be attempted, and the patient if sufficiently conscious should be instructed to expire very deeply, coughing with the act, while he inspires as shallowly as he is able. This manœuvre has succeeded in dislodging a tooth which had passed into the trachea.

There is, however, a danger that inversion may cause the foreign body to lodge in the larynx and so excite spasm, and should this occur the trachea must be at once opened. Failing these measures, if the patient be dyspnœic and death by asphyxia seems imminent, the trachea must be opened by tracheotomy* (see Chap. X.). When the asphyxial symptoms are due to the patient having vomited into the face-piece, it will usually suffice to forcibly open the mouth and sponge away the vomitus. However, solid food may become impacted in the rima or

* The operation of laryngotomy which some authorities recommend in these cases is less effectual.

in the œsophagus occluding the larynx by pressure, and so necessitate the opening of the trachea below the obstruction.

Mania is a rare complication following nitrous oxide inhalation, which has occurred in persons subject to mental disease.

Epileptic fits may occur during the induction or following anæsthesia, but beyond taking care that the tongue is not bitten no special treatment is necessary.

Hemiplegia and apoplectic seizures have been recorded as occurring after nitrous oxide, but are extremely rare. When there has been much straining and cyanosis, ocular ecchymosis and even retinal hæmorrhage may result after this anæsthetic.

The Use of Nitrous Oxide in the Puerperium and in Disease.

Pregnant women, provided they be not within a very short period of their accouchement, are not prejudicially affected by this anæsthetic. The shock of even a minor operation is quite as likely to provoke premature delivery as taking nitrous oxide. The child appears also to be quite unaffected, as one would expect, since its oxygen tension is habitually low, and further because the elimination of nitrous oxide from the blood is very rapid. Especial care should be taken in administering nitrous oxide in these cases and all asphyxial complications must be avoided, as the nervous system is peculiarly liable under such conditions to receive strong impressions and is easily thrown off its balance. Hysterical emotional outbursts if they occur will certainly be attributed to the inhalation, so that unless imperatively called for, opera-

tive measures should be deferred until after parturition. In the early months of pregnancy vomiting may be excited by nitrous oxide.

Lactation is not in the majority of cases prejudicially affected by nitrous oxide gas. **During menstruation** women may safely take this anæsthetic, with the reservation that since their nervous system is at this time less stable than ordinary, these patients will be a little more likely to be "upset," hysterical, and so on. It is noticed elsewhere that erotic hallucinations under nitrous oxide are more prone to occur at the "monthly period" than at other times.

Advanced age, as such, offers no reason for declining to administer nitrous oxide, patients over ninety having taken it successfully. When great **vascular feebleness** exists, there is more risk, as the greater tax imposed upon the heart by checking oxidation in the lungs, and so impoverishing the tissues, may provoke syncope. However, with due care and watchfulness even the very feeblest can take nitrous oxide with impunity. In practice I have found it wise to administer a little ether in conjunction with the gas when great circulatory enfeeblement is present.

In extensive lung disease, especially in phthisis, when hæmorrhage has been known to have occurred, nitrous oxide must be given with caution, as there is danger of exciting fresh bleeding from the lungs. According to Mr. Woodhouse Braine, narcosis deepens in phthisical patients after the withdrawal of the face-piece, and so special care is needed in the management of such cases. It is probable that this is really due to enfeebled expiration preventing the usual elimination of the anæsthetic.

Heart disease, except when the tendency to syncope is considerably increased, is no contra-indication to giving

nitrous oxide. In all cases it is necessary to weigh in one's mind which will be most likely to jeopardise the patient's welfare—the performance of an operation without an anæsthetic, or the giving of the anæsthetic. Broadly it may be stated that if the patient can support the shock of the operation, he will certainly survive the anæsthetic. **Valvular disease,** unless marked want of compensation is present, is not contra-indicatory to nitrous oxide inhalation. When the heart is greatly **dilated** and the **hypertrophy** has failed to overcome the obstructed circulation, or when marked muscular degeneration of the heart fibres has taken place, there is necessity for caution, and of such patients the most anxious care should be taken. In all the cases referred to in this section it is best to employ nitrous oxide and oxygen, or air, rather than to rely upon nitrous oxide by itself.

Deaths from Nitrous Oxide Administration.

Several deaths have been imputed to the use of this agent, but it is doubtful whether any of the cases recorded were directly due to the physiological action of nitrous oxide gas. In some instances insufficient narcosis was maintained, and as a result the patient *felt the pain*, and syncope ensued. In others, either the entire gag or a portion of it slipped, and found its way into the patient's larynx, there to excite spasm and suffocation. A fuller account of these fatalities will be given at the end of this chapter.

2. **Nitrous oxide given with air.**—The most accurate method is to work with gasometers containing definite mixtures, but it is necessarily only applicable for

hospitals and so will not be described here.* When nitrous oxide is given and air allowed to enter as the anæsthetist deems it expedient, one of two plans is followed, (1) the air is given intermittently, (2) it is given in small quantity throughout the whole administrations the amount being increased or lessened as the symptoms seem to indicate. Paul Bert's experiments with nitrous oxide and air, gave unsatisfactory results, because he attempted to employ only fixed proportions. Mr. Tom Bird informs me he used air with gas, as early as between 1870 and 1880, but I believe his results were not formally published. Mr. Rowell has spoken well of the plan of intermittent admissions of air,† and insists upon the importance of preventing air getting into the nitrous oxide bag. He employs the apparatus described on p. 72. There is little doubt that most of the older forms of apparatus allowed a leakage of air, so that the patient was really breathing a mixture of gas and air. This fact no doubt explains the marked differences shown by various patients under the influence of nitrous oxide. No attempt was made to limit or graduate the amount of air given.

Continuous inhalation of gas and air.—Mr. Carter Braine has devised a face-piece figured below which is intended to supply a ready means of admitting a varying proportion of air.

Mr. Braine‡ gives the following directions for administration :—" Commence with all the holes covered (fig. 18), and after the patient has taken two, or perhaps three, inspirations of gas, and the gas-bag has become lax, turn on one or two of the air-holes. Do not allow the gas-bag to become distended, or very little, if any, air will enter

* See Dr. Hewitt's "Anæsthetics," 1901, pp. 235 *et seq.*

† *Journal of Brit. Dental Association*, 1892, p. 669.

‡ *Journal of British Dental Association*, April, 1895.

through the perforations. Turn on more holes according to your patient's condition."

In the use of other forms of apparatus the following plan is adopted. The slot, which, when closed admits gas, and when open air, is left so that a chink remains patent. The chink can be made wider or narrower as the case seems to require. No special apparatus is necessary, those described on pp. 69 and 72 answer well.

Intermittent supply.—The patient inhales gas in the ordinary way until presumably all the residual pulmonary air is exchanged for nitrous oxide. The number

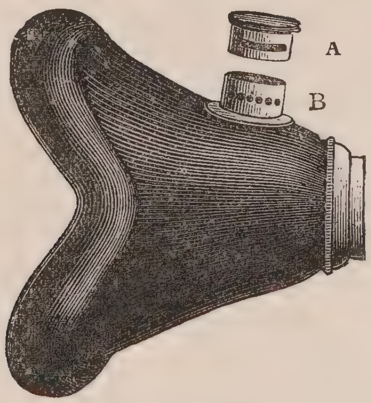


FIG. 18.—*A*. Cap with slot. *B*. Mount with six holes for admitting varying proportions of air. (Carter Braine's face-piece for giving air and nitrous oxide.)

of respirations required to produce this, varies with the vital capacity of the individual and the force of his respirations. As a rule children take ten or twelve good inspirations, women a few more, and men about twenty. It must be remembered that although the normal of respiration is seventeen per minute for adults, the breathing is much more rapid under anæsthetics, so that as a rule, it is necessary to admit air before a minute of inhalation has passed. When the quickened breathing, due in large measure to excitement, is settling down into slow, steady,

regular respirations, and the face is losing its bright look and growing dusky, a breath of air is admitted by quickly closing the valve which usually admits gas, while air is permitted to enter, taking care that *an expiration followed by an inspiration* is performed while the air-way is open. Nitrous oxide is then inhaled for a few breaths and the dose of air again given. If the cyanosis is marked and jactitation or stertor appears, two or even three breaths may be given consecutively. When the patient is fully under, it is wise to give one breath of air and then five or six of nitrous oxide, and then remove the face-piece for the operator to commence his proceedings. The time occupied in producing anæsthesia may be a minute and a half, two or even three minutes, and the period of anæsthesia is usually longer than when only nitrous oxide is employed. I have obtained a workable seventy seconds by this method.

For prolonged operations.—The patient is put under with nitrous oxide and air as described above and then the mask removed, and as soon as any signs of returning consciousness appear more of the anæsthetic is given. This plan will enable operations lasting twenty minutes or even longer to be performed, although there seems no advantage in using nitrous oxide for prolonged anæsthesia.

3. **Nitrous oxide with oxygen.**—The apparatus devised by M. Fontaine for carrying out Paul Bert's method of giving these gases under pressure, has practically gone out of use, so a mere mention of it will suffice. The name of Paul Bert must, however, always be remembered with honour in this connexion, for his classical

researches (*Compt. rend. de l'Acad. des Sc.*, 1878, 1879, &c.) paved the way for the present simpler and better methods.

Hillischer's apparatus I have used, but have not found it so satisfactory as those devised by Dr. Hewitt and Mr. Rumboll.*

Dr. Hewitt's apparatus.—Two bags completely separated by an indiarubber division contain the two gases. These are severally connected by tubes arranged one within the other with the steel cylinders containing the oxygen and nitrous oxide respectively. The oxygen passes into a small chamber which is separated from the mixing chamber, but can escape into the latter by one or more perforations in the wall when the revolving inner drum is turned. This is moved by a handle attached to the indicator. The figures given below show the apparatus complete (fig. 19) and the various portions of the regulating stopcock with the mixing chamber are seen in fig. 20.

Success in the use of this method can only be obtained by the most careful attention to carrying out its details. The patient should be so placed that the face-piece can fit accurately, as it is important that no air enters between the air cushion and the face. The air cushion should be distended and as the mask is pressed firmly upon the face sufficient of the air should be allowed to escape from the cushion by turning the tap until an accurate co-adaptation is obtained. The head should be in the normal line of the body, and of course, as in the case of any anæsthetic being given, all clothing should be loose. Since it is most important that the various valves are working properly, it is well, after fitting on the face-piece and before turning on

* These figures of his apparatus are lent me by Dr. Hewitt, and appear in his book, "The Administration of Nitrous Oxide and Oxygen for Dental Operations," Ash and Sons, London, and for those of Mr. Rumboll I am indebted to the courtesy of Mr. Sidney Rumboll and Messrs. Down. The description of Dr. Hewitt's apparatus is largely taken from the above work.

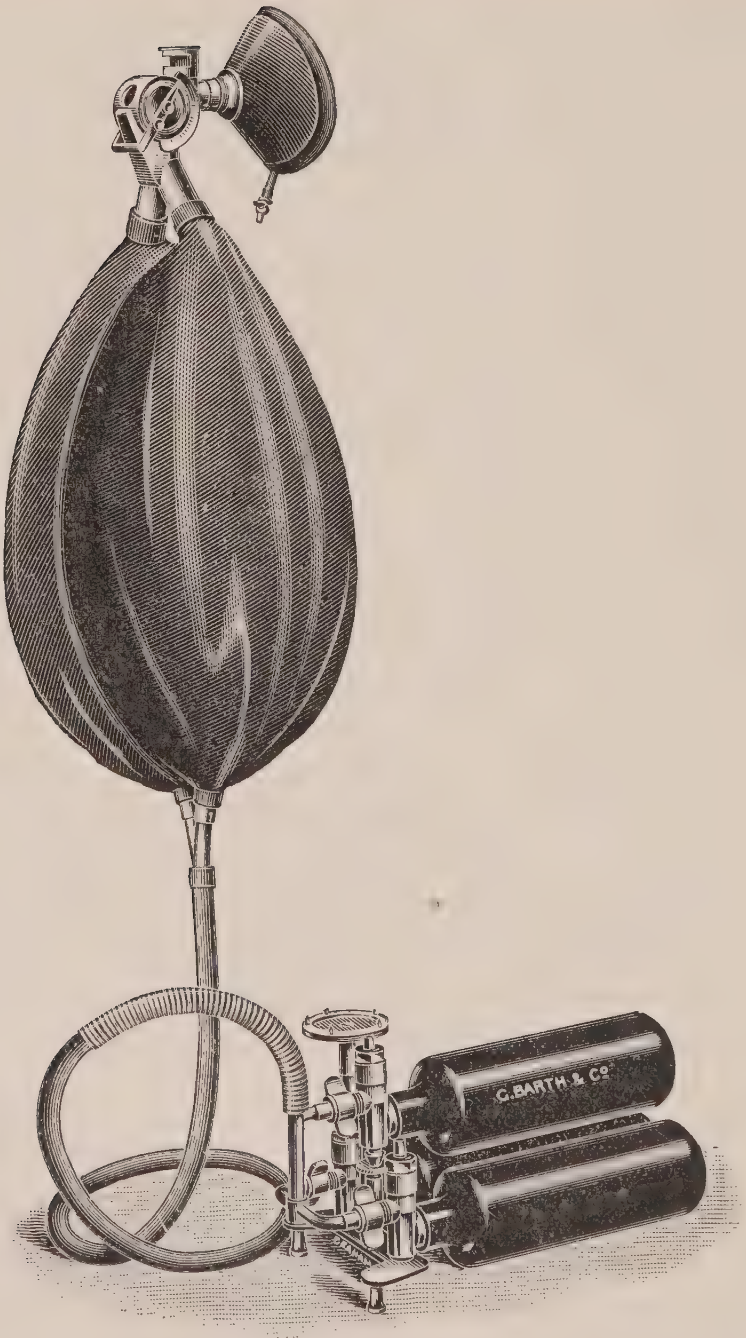


FIG. 19.—Dr. Hewitt's apparatus for giving nitrous oxide gas with oxygen.

the gases from the cylinders, to allow the patient to breathe two or three times through the apparatus (fig. 19).

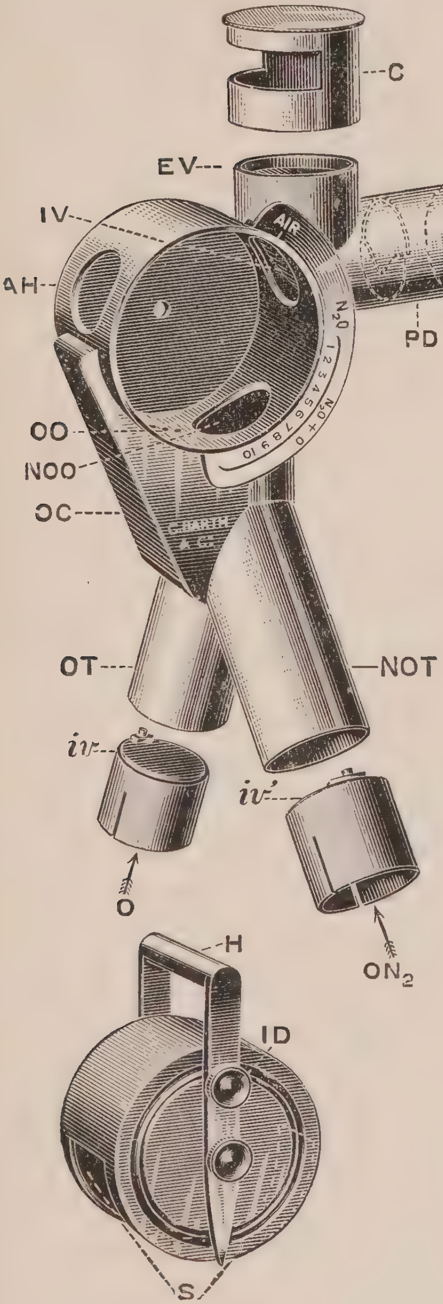


FIG. 20.—*NOT*. Tube to nitrous oxide bag. *NOO*. Its opening into mixing chamber. *OT*. Oxygen tube connected with oxygen bag and opening into little oxygen chamber *OC*. There are ten minute holes between *OC* and mixing chamber, three of these only are shown in figure at *OO*. *iv* and *iv'* are removable valves fitted to *OT* and *NOT*, which act during inspiration and prevent diffusion of the gases into the bags. *AH*. Air-hole. *IV*. Main inspiratory valve. *EV*. Expiratory valve, *C*, its chimney, which prevents air being drawn back through *EV*. *ID*. Inner drum. *S*. Slot cut in it. *H*. Handle rotating drum and opening oxygen holes. As the drum rotates, the air, nitrous oxide, and oxygen inlets are respectively opened and closed.

The handle attached to the indicator is then to be turned so that the latter points to "2," thus permitting a small quantity of oxygen to mix with the nitrous oxide. If the

patient is a child, is anæmic, or shows signs of rapidly developing cyanosis it is well to push the indicator at once to "4." After a few breaths, should any change of colour appear, the indicator should be pushed to 5 and 6 or onward as the judgment of the administrator suggests. The appearance of signs of cyanosis, stertor, muscular twitchings, are indications for allowing more and more oxygen to enter the mixing chamber, while the presence of a ruddy red flush over the forehead, an apnœic condition without blueness, the commencing of purposeful muscular movements, signs of excitement, talking, persistent consciousness, are indications that the patient is getting too much oxygen. In this case the indicator can be turned back to "2" or even "0" until quietude is established. At this stage it is well to again allow some oxygen to enter, and if the patient takes this percentage with success, to allow him to inhale for a minute or so after anæsthesia has developed itself. In this way a more prolonged period of anæsthesia is obtained. By a slight addition to the apparatus, not, however, shown in the figure, a fuller supply of oxygen can be obtained. This will be necessary when the apparatus is used for prolonged anæsthesia. Dr. Hewitt prefers to have the bags only partly distended and insists upon the importance of maintaining them as nearly as possible of the same size throughout the administration. If, however, the symptoms are carefully watched I think perhaps the best results are obtained by keeping the oxygen bag about two-thirds full, and by varying the fulness of the nitrous oxide bag as the symptoms seem to demand. It must, however, be remembered that filling the one bag exerts pressure upon its companion through the dividing septum, and hence neither bag should ever be filled to distention. The possibility of a small opening between the bags should be

borne in mind if anomalous symptoms caused by an excess of oxygen in the mixture become apparent. At the point when the patient is anæsthetised it is my custom to discontinue the supply of either gas from the cylinders and to allow the patient to breathe the mixed gases without any added pressure from the inrush of a fresh supply.

The signs of unconsciousness are not so clear as in the case of nitrous oxide given by itself. The inhalation will occupy in many cases two minutes or even longer.* Indeed, the longer the period of induction is, provided too much oxygen has not been admitted, the more satisfactory will be the anæsthesia. The signs of anæsthesia are soft "distant" snoring breathing, fixation of the ocular globes and an insensitive conjunctiva. The muscular system should be fully relaxed. The pupils usually remain of normal size. The **period of anæsthesia** varies within wide limits but is usually slightly longer than when nitrous oxide is given alone. **After effects** such as **languor, nausea, vomiting, headache, slight vertigo,** following the use of nitrous oxide diluted with oxygen are somewhat more frequent than when nitrous oxide is used alone. This is probably due in part or entirely to the more prolonged period of the induction of anæsthesia. The patients are longer in recovering their wits and occasionally remain in a dazed state for some minutes. The **after effects** following the use of nitrous oxide and air are practically those already described in speaking of nitrous oxide. In the case of nitrous oxide when used with oxygen, the only after symptom of any moment is that of nausea with or without vomiting. This is rather more frequent as a complication when this mixture is employed than when nitrous oxide is given alone. On the other hand, the evil effects of cyanosis and its sequelæ are

* Dr. Hewitt gives his average as 110 seconds.

conspicuously absent after nitrous oxide and oxygen. No case of death which can be regarded as being the direct result of this mixture has been reported, so that we must regard the method as extremely safe.

Mr. Sidney Rumboll's apparatus consists as is

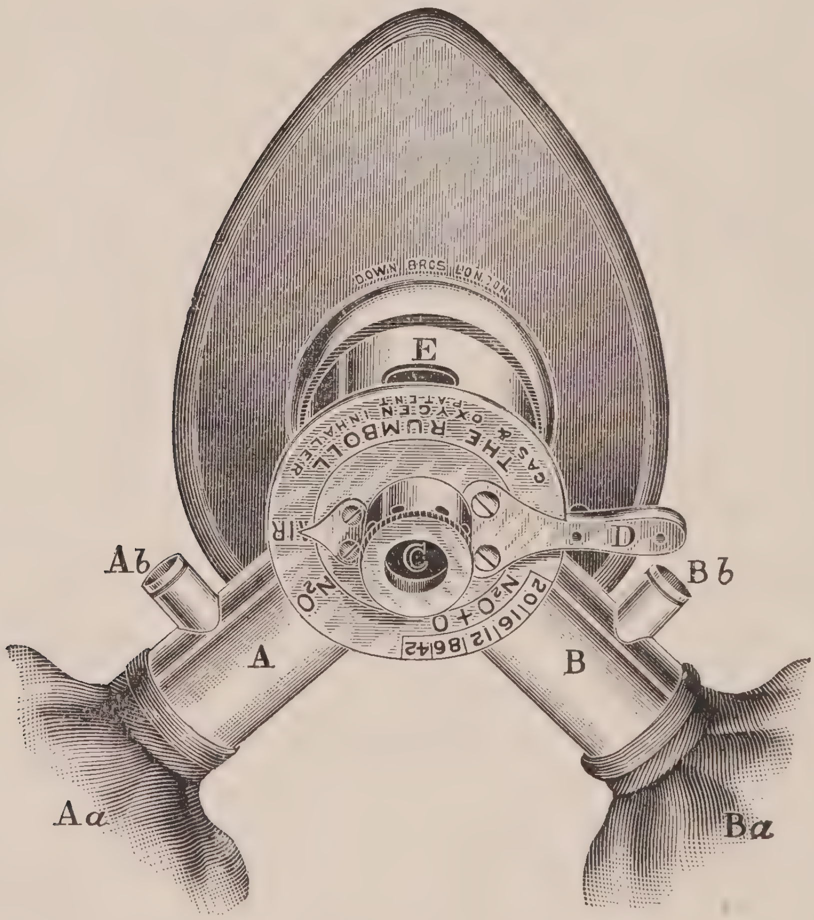


FIG. 21.—Mr. Sidney Rumboll's apparatus.

shown by fig. 21 of two bags, one for oxygen and one for nitrous oxide, and a face-piece fitted with a regulating stopcock, permitting the patient to inspire nitrous oxide, oxygen, or a combination of these gases in different proportions. There is an expiration valve (C), two tubes A*b*

and B*b* communicating with the cylinders and filling the bags A*a* and B*a* respectively, while A and B convey the gases to the stopcock. The indicator (D) is turned to air, N_2O, N_2O+O or O, according as the patient is to breathe air, nitrous oxide, nitrous oxide and oxygen, or oxygen. The figures opposite N_2O+O indicate approximately the percentage 2, 4, 6, &c. of oxygen.

For use the face-piece is fitted to the stopcock, so that the slot in the mount is in a straight line with the air-hole E. The indicator D is turned to "Air," and the bags are filled three parts full of oxygen and nitrous oxide respectively, A*a* being the nitrous oxide, B*b* the oxygen bags.

The face-piece is then carefully adjusted and the patient breathes first air. The indicator being turned to N_2O, he has nitrous oxide. Subsequently the indicator is turned towards O according to the percentage of oxygen required. If from collapse, or for any other cause, it is desirable to perfuse the lungs with oxygen the indicator is turned to O. The apparatus is extremely simple and useful, not only for brief but for the prolonged employment of nitrous oxide and oxygen.

Experience alone can enable the administrator to regulate the amount of oxygen required for any given case. It should be remembered that the addition of oxygen is simply made to enable a patient to go on breathing nitrous oxide without suffering from oxygen starvation. In other words oxygen is an adjunct and not an adjuvant anæsthetic such as ether, so that as little should be given as is consistent with maintaining the required oxygen tension in the pulmonary air cells. Thus **full blooded men** in robust health require less oxygen, **alcoholic subjects** are apt to become excited if oxygen is given at all freely at first. **Children,** the anæmic, and persons

in **feeble health,** or who suffer from any disease giving rise to **cyanosis** and **venous engorgement,** especially where the **circulation is feeble,** require more oxygen, and frequently the quantity given must be rapidly increased at the commencement of inhalation, even if the amount is lessened later on.

4. **Nitrous oxide in combination with ether.**—In cases in which more time is required than nitrous oxide gives, the use of ether—but in conjunction with the gas—is to be recommended. The apparatus which I have found most serviceable is what was called Clover's Gas and Ether Inhaler, although since Mr. Clover's time many useful alterations have been made in its construction. The reader is referred to page 147 for particulars of this method.

5. **Nitrous oxide in combination with chloride of ethyl.**—The employment of nitrous oxide antecedently to chloride of ethyl is described on page 268, and the reader is referred to this section.

Nitrous oxide given from a gasometer.—Where a gasometer is kept a modification of the above apparatus is in use. A long tube screws on to the efferent pipe of the gasometer, conveying the gas to a bag of 2 or 3 gallons' capacity. This may be connected directly with a face-piece or conveyed to it by another length of tubing, and by using a three-way-cock it is easy to combine this apparatus in gear with Clover's small ether inhaler, or with apparatus figured on page 72.

6. **Prolonged nitrous oxide administration.**—In cases in which the surgeon requires access to the mouth, nitrous oxide may be administered through the nose, as described above, p. 87. The only difficulty in the management of these cases is, avoiding on the one hand cyanosis, and on the other, undue admission of air, and these extremes can with practice be avoided. When the operation is not upon the mouth, nose or buccal cavity, by giving air alternately with nitrous oxide a prolonged anæsthesia can readily be obtained. As soon as the patient shows the signs of complete narcosis the face-piece is lifted and air admitted for three or four breaths, when it is replaced and more nitrous oxide given. If cyanosis and jactitation are avoided an extremely satisfactory anæsthesia can be indefinitely obtained, only limited indeed by the supply of nitrous oxide. There is apt to be some rigidity in the muscles after a few minutes' inhalation, and the after effects are not always satisfactory, headache and even sickness not uncommonly occurring.

Death During Nitrous Oxide Administration.

In the return of deaths published by the *Lancet** thirteen are given. The causes assigned are (1) asphyxia; (2) fright (imperfect anæsthesia); (3) congestion of the lungs which was not known to be present when the anæsthetic was administered; (4) phthisis (last stage); (5) asphyxia due to impaction in the larynx, (*a*) of a broken gag, (*b*) of a molar tooth; (6) syncope (three cases), shock of extraction of a tooth in partial narcosis, while in one case the cause

* Report of the *Lancet* Commission appointed to investigate the subject of the administration of chloroform and other anæsthetics, from the clinical standpoint, 1893, p. 175.

of death assigned was tight lacing interfering with respiration and circulation. Three other cases are given in this report in which respiration failed, but the patient's life was saved by prompt recourse being had to artificial respiration. In a paper written by the author* sixteen deaths are tabulated and classified, but some of these are identical with those mentioned above, three additional being given. Dr. Maughan† records another case similar in many aspects to a fatality which occurred at a London Hospital a few years back.

The references are given that a full study can be made of the cases. It is proposed here to give merely a general summary of the actual causes of the deaths. In most cases the death could not have occurred simply as a result of nitrous oxide inhalation. In at least three cases the patients suffered from conditions which rendered the upper air-ways constricted, and liable to complete closure if any marked venous engorgement arose, such as might occur during the inhalation of nitrous oxide. Œdema, inflammatory swelling affecting the tonsils, tongue, larynx and adjacent tissues, are extremely likely to cause asphyxia when nitrous oxide is inhaled, and patients suffering from such conditions are not satisfactory subjects for this anæsthetic. A goitre may produce dangerous symptoms.‡ Spasm of the larynx has been reported and its possible supervention, even without the mechanical irritation caused by fragments of teeth, &c., must be remembered, as death has resulted from impaction of foreign bodies in the larynx when the patient was under nitrous oxide. This spasmodic closure probably was the cause of one of the deaths and followed inhaling impure and irritating

* *Brit. Dent. Journal*, Oct. 1895, p. 865.

† *Transactions of Society of Anæsthetists*, vol. vi., p. 12.

‡ See the report of an interesting case by Mr. Carter Braine in vol. vii. of the *Transactions of Society of Anæsthetists*.

gas. Cough and difficulty of respiration should always suggest this possible complication and the gas should be tested before the patient is allowed to inhale it, if the first attempt causes severe laryngeal irritation. The administrator can easily determine whether the gas is impure by himself inhaling a few breaths of it. As to syncope, undoubtedly deaths have arisen from heart failure; these result either from fright and incomplete anæsthesia alone, or more usually these states are contributory to inducing cardiac failure in the anæmic and feeble.

Suffocation, either from foreign bodies or vomit, sponges, &c., blocking the air passages, have in some of the cases caused death, a death which arose from mechanical causes and not from the action of the anæsthetic.

It is difficult to be sure whether nitrous oxide has ever been directly the cause of death. If it is used in an impure form, or if given to persons suffering from some asphyxial symptoms in whom respiration is already seriously interfered with, nitrous oxide is undoubtedly a dangerous anæsthetic and potent to lead to serious results. The heart seems seldom primarily affected, but if feeble and asthenic it is certainly liable to fail should the respiration be in any way hampered, so that syncope can thus be brought about and may prove fatal.

CHAPTER IV.

ETHER.

Ether or ethyl ether $(C_2H_5)_2O$, formerly called sulphuric ether, more accurately known as ethyl oxide, was discovered in 1540 by Valerius Cordus and named by him *oleum vitrioli dulce.* In 1730, Frobenius substituted its present designation. Ethyl ether must be carefully distinguished from "compound anæsthetic ether," a mixture of hydride of amyl and rectified ether which is used solely for producing local anæsthesia.* "Compound anæsthetic ether" cannot be safely used for producing general anæsthesia, indeed the attempt has resulted in fatal accidents.

Chemical and physical properties.—Ether is a limpid, translucent highly volatile liquid, of a penetrating odour and has a burning taste, which is followed by a sensation of cold and numbness. Ether is the resultant of the dehydration of ethylic alcohol by sulphuric acid. When pure it does not redden litmus, it has a sp. gr. of 0·713 and a boiling point of 95° F. It crystallizes when cooled to below 200° F. in fine white laminæ. Ether does not mix completely with, but is slightly soluble in water; it is freely miscible with alcohol, benzine, petroleum spirit and chloroform. Applied to the skin, it gives a sensation of intense cold caused by the extreme rapidity of its evaporation. Ether is highly inflammable, its vapour when mixed with air is liable to explode if brought in contact

* See Chapter XI.

with flame, it is hence important to avoid placing it in the proximity of lighted gas jets, candles, &c., and to refrain from pouring it out of one receptacle into another in such surroundings. Explosion has followed when ether was incautiously held near an electric lamp. The following description of the varieties of ether is of importance, as some kinds are better adapted for producing general anæsthesia than are others.

Prepared from ethylic alcohol:—

Æther (B.P.), sp. gr. 0·735, boiling point below 40·5 C. (105° F.), contains 92 % by volume of ethyl oxide. This substance is not suitable for use as an anæsthetic although it is occasionally so employed.

Æther purificatus (B.P.), sp. gr. not exceeding ·722 and not below ·720, is in use both to produce general and local anæsthesia.

Prepared from methylated spirit:—

Absolute ether; methylated. Sp. gr. 0·717-719. Not suitable for general but answers well for local anæsthesia.

Rectified ether, sp. gr. 0·720, suitable for general anæsthesia.

The rectified ether prepared from methylated spirit, when properly made, is the most satisfactory preparation for use as an anæsthetic. It must be remembered that careless manufacture and prolonged exposure to light and air greatly affect the results of etherisation, causing coughing, suffocation, and even dangerous after effects. It is best to have the ether put up in small bottles holding 4 or 6 ounces so that when once opened the supply can be consumed. The bottles should be properly stoppered and kept in a cool dark cupboard.

Many persons, however, prefer the "æther purificatus" prepared from ethylic alcohol, alleging that patients re-

cover more rapidly and are less liable to be affected by impurities. Impurities are, however, by no means always present in the ether derived from methylated spirit.

Ether, if kept in hot places and in imperfectly stoppered bottles and exposed to light and air, is liable to undergo oxidation, acetic acid and other products form, and the reagent is thus rendered unfit for use. Sir William Ramsay has pointed out that shaking the ether in a bottle containing metallic mercury will remove the impurities which drop as a grey sediment and the pure ether can be decanted off.

Impurities.—Ether should satisfy the following tests :—

Sp. gr. ·722 to ·720. On evaporation should leave no residue or abnormal odour or coloration on filter paper.

It should dissolve in an equal volume of *carbon disulphide* (absence of excess of water).

It should distil at not below 94° F. (absence of methylic ether).

The addition of potassium hydroxide should produce no effect (absence of aldehyde).

No change in wet blue litmus paper after contact for 24 hours (absence of acid).

Ether should dissolve without coloration when dropped into sulphuric acid kept cool during the test (absence of organic impurities).

Acids : sulphuric and sulphurous are detected by the precipitate they give with barium chloride ; acetic acid produces a deep-red colour upon the addition of an iron salt.

Fusel oil and other objectionable impurities may be detected by leaving a greasy stain on paper and a disagreeable acrid smell when the ether is evaporated from it, as well as by the cough excited during inhalation.

General properties and uses.—Ether is an exhilarant and finally an anæsthetic.*

As a general anæsthetic ether possesses an advantage over nitrous oxide gas in so far as it produces a more prolonged and profound narcosis. It is believed to be safer than chloroform as it is not a protoplasm poison, does not prejudicially affect the heart and raises blood pressure. It is therefore to be recommended for general use. The allegation that ether produces more dangerous after effects than chloroform has not been proved, indeed, very many of the reported disadvantages of ether are undoubtedly due to faulty administration rather than any inherent peril in its action upon the tissues. This point will be again considered when the after effects and sequelæ are considered.

It must, however, be borne in mind that ether has its limitations, a fact which is often overlooked with the result that failure and disappointment follow in certain cases, both of which might have been avoided had a more careful selection of the anæsthetic been made.

Contra-indications.—Cases in which ether should not be used :—

1. In protracted operations about the mouth, jaws, nose or pharynx, which necessitate the mouth and nose being uncovered. Since consciousness rapidly returns when the supply of ether is discontinued, there is not time for the prolonged surgical procedure.

2. In all operations which require the employment of the actual cautery, or lighted candles, lamps, &c., near the mouth.

In the following conditions the advisability of using ether ought to be carefully weighed.

Persons who are suffering from *bronchitis*, the *emphy-*

* For the use of ether to produce local anæsthesia see Chapter XI.

sematous (if the condition be very pronounced), and as a rule *asthmatics*, bear ether badly, since it excites cough and may clog the bronchial tubes with a quantity of excessive secretion. On the other hand, ether often assists the breathing of asthmatics if pure and copiously diluted with air.

In *renal disease*, when extensive, ether is said to induce suppression of urine, so that if given at all in these cases it should be used with the utmost caution.

The vascular excitement to which ether gives rise contra-indicates its use for persons with *rigid* and *atheromatous arteries*, or in whom circulatory perturbation is likely to be harmful. It is obvious that when *cerebral hæmorrhage* from rupture of an artery has once occurred, ether might, by increasing arterial tension, induce a repetition of so dangerous an accident. Some few instances of this have occurred.

In *infants* and very *young children* ether may sometimes produce pulmonary trouble from its irritating effects upon the delicate mucous membrane of the respiratory tract.

Although, in selecting an anæsthetic, it is well to weigh these considerations, yet I think few of them are insuperable objections to ether, except perhaps in very marked cases of disease.

In *tropical climates* it is both difficult to obtain and to keep ether, and also to administer it satisfactorily.

As ether often provokes rapid breathing and not infrequently coughing before complete narcosis has been obtained, it should not be used when these are prejudicial to the patient, or to the success of the operation. Many surgeons object to ether in abdominal operations both on account of the inconvenience arising from the rapid laboured breathing often caused by it, and because they

consider the patients are especially liable to pulmonary troubles after the operation.

In *operations upon the brain* when turgescence and dilatation of the blood-vessels are undesirable, ether should not be used; and according to Prof. Wood it is contra-indicated in the presence of brain tumours.

Physiological Action of Ether.

Hermann asserts that ether causes the destruction of the red blood corpuscles. Dr. Da Costa,* of Philadelphia, has found that it produces a marked diminution in the hæmoglobin, more especially in persons whose blood is pre-existently diseased (*e.g.*, anæmia, chlorosis, &c.). Bernard showed that infusoria were readily influenced by ether, and Sternberg has demonstrated that it destroys pathogenic bacteria. The lower animals are affected in a similar way to man.

When the pure vapour is first inhaled it induces a burning sensation in the mouth, pharynx and throat, and a feeling of impending suffocation. It appears to act in two ways; indirectly through the nerve centres as a powerful deliriant and anæsthetic, and directly upon the endings of the nerves supplying the pharynx and respiratory tract. Thus, it increases the flow of saliva, and causes considerable discharge of watery secretion from the mucous membrane of the respiratory tract. Its extreme volatility makes it exert a marked cooling action upon the skin or mucous membranes when allowed to come into contact with them; and the vapour may, if injudiciously employed, excite catarrh. Ether is absorbed both by the mucous membrane of the respiratory tract and that of other mucous surface, *e.g.*, the rectum. When ether

* "The Blood Alterations in Ether Anæsthesia," *Medical News*, March, 1895.

vapour is given by the rectum, the vapour is perceptible in the breath after a few minutes.

The nervous system during etherisation becomes profoundly affected. The cerebrum first succumbs. Excitement and hallucinations occur, the patient believing that he is engaged in some active exercise; he often grows pugnacious or amatory, or pursues his habitual work or pastime he may struggle and cry out. Soon his speech becomes thick and inarticulate, his struggles cease and his mind no longer controls his movements. The *sensory nerves* of the spinal cord then fail to convey impressions from without, although stimulation of the motor nerves induces movements. Later, the motor nerves also cease to respond, save to powerful electrical excitation (Longet). Waller has shown that isolated nerve is directly influenced by ether, and that ether is about seven times less potent in this respect than chloroform. The *medulla oblongata* becomes next affected; at first sensory impressions fail to reach it, finally its centres become paralysed, respiration is arrested, and the heart ceases to beat. It appears that these results are due to the direct action of ether conveyed by the blood to the nervous centres, since they occur after section of the pneumogastric nerves, or when the anæsthetic is injected directly into the veins. Hence it would seem that ether, directly affecting the centres, acts first as a stimulant and later as a paralyzant. When artificial respiration is maintained, the heart will continue to beat for a prolonged period, and this even in spite of very large quantities of ether being taken.

Ether narcosis may be divided into five degrees (Snow) as in the case of chloroform.

The phenomena of these may be summarised as follows:—

(1) All the effects that exist while consciousness is still

present; a burning pungent taste and smell; buzzing or singing in the ears; inability to recognise objects in the proper places, as they appear distant and unduly large; the speech of bystanders often imperfectly understood and misapplied. (2) The mental faculties become impaired but are not suspended, illusion, semi-delirium, excitement and muscular movements appear but are of a subjective rather than of an objective significance. Semi-anæsthesia exists, and pain even if slightly felt is seldom remembered as pain upon awakening. This is probably the degree of which the French surgeon Péan wrote when he described patients who moved freely and appeared conscious, but were nevertheless oblivious of the surgeon's knife. Rigidity and muscular spasm usually appear as the patient passes into the next degree. (3) All the mental faculties are in abeyance, the muscles relax, and no movement of the voluntary muscles takes place, nor is any pain felt. Occasionally patients will wrinkle up their brows or even moan throughout an operation, but these are not indications of sensation or pain. (4) Paresis of the centres of the medulla oblongata supervenes with gradual failure first of respiration and then of circulation; and (5) death results from destruction of these centres and consequent stopping of the heart. Patients may be restored during the fourth degree by the performance of artificial respiration, but not when the circulation has ceased in the fifth.

Duret* divides ether narcosis into two periods:—(1) anæsthetic sleep—cerebral excitation, followed by abolition of cerebral function and disappearance of sensibility; and (2) anæsthesia—muscular resolution and abolition of reflexes. Dastre points out that the order in which sensation is lost is one of primary importance. The following is the succession in which sensibility disappears:—integu-

* Quoted by Prof. Dastre, "Les Anæsthétiques," p. 77.

ment of limbs and trunk, next that of the face, then that of the nasal mucous membrane, followed by that of the eyes, the integuments, the organs of sense, the ear being the last to fail. It may be noted that the genital organs and rectal mucous membrane, retain sensibility to stimuli for a very prolonged period. The knee jerk is increased in the early stage of etherisation (Eulenberg), and even in the second degree ankle and knee clonus are apt to develop, and as a rule more profound narcosis will cause the phenomena to cease.

In the rhythm of *respiration*, ether brings about marked changes. If the full strength of ether vapour be allowed to impinge upon the glottis, the adductor muscles are thrown into spasm, and the rima glottidis becomes temporarily closed. Ether may thus cause laryngeal spasm (Kratschmer). Indeed ether has been shown by Horsley and Semon to exert a marked local action upon the laryngeal muscles. These observers have demonstrated that this differs according to the depth of the anæsthesia induced. Slight narcosis causes adduction, while deep etherisation produces abduction of the vocal cords, and these results obtain alike with strong or weak faradic currents, and whether the recurrent laryngeal nerve is divided or left intact.

During ether inhalation, the respirations are at first hurried and deep, subsequently they become slower and more shallow, and eventually, if ether is pushed to a dangerous extent, cease altogether. This slowing and final stopping appear to be due to ultimate poisoning of the respiratory centre.

Wood points out that irregularity and even cessation of respiration may occur in the early stage of etherisation, and is due to irritation of the nerve fibres of the trigeminus and vagus, this inhibition may be overcome by

deepening the anæsthesia and so annulling the reflex. Kratschmer asserts that he has seen spasm of the glottis occur. Such respiratory perturbations must of course be carefully distinguished from those due to over-narcotisation of the medulla, which can only occur late and in profound narcosis.

The *heart's action* is at first excited and increased in force; later it quiets down, and may even grow somewhat weaker, though such weakening is always trifling. The *blood pressure* is increased until very deep narcosis is present, when a slight fall of pressure occurs. A peripheral vascular dilatation reveals itself in flushing and rubescence of the skin, together with sweating and a roseolous rash.

The presence of the ether rash is pretty constant, but occurs more commonly in women and children. It usually is first seen about the neck and shoulders, but may cover the arms, the chest, and even extend to the thighs. It lasts for a few minutes, sometimes ten or fifteen. It has probably no significance beyond showing the action of ether upon the sympathetic system. Its appearance is usually synchronous with the relaxation of the muscles.

Ether appears to act as an irritant to the *kidneys* although healthy kidneys are but little affected by it. Statistics show that pre-existing albuminuria is slightly increased by ether, but that chloroform is more likely to cause albuminuria in those who have presumably healthy kidneys.* The amount of renal derangement is certainly

* On the other hand, Drs. Thomson and Kemp have shown by experiments on dogs, that albuminuria with lessening of the amount of urine occurs after ether inhalation, but only slight albuminuria without suppression of urine after chloroform inhalation. As I have pointed out above, these results do not agree with those at which I arrived when investigating this matter with the aid of Dr. Levy. I think that probably excessive doses of ether were employed by Drs. Thomson and Kemp, and as a result toxic effects were produced.

dependent very largely upon the quantity of the anæsthetic which is employed. As less chloroform will produce and maintain anæsthesia when given from an efficient regulating inhaler such, for example, as that of Mr. Vernon Harcourt, it is better in prolonged operations upon the kidneys, or in the case of patients whose kidneys are extensively diseased to rely mainly upon chloroform. There is no objection in most instances to inducing anæsthesia by nitrous oxide gas and ether, and maintaining it by chloroform or a mixture.

According to Dr. Sansom, in the earlier stage of etherisation, capillary constriction takes place. In some patients who are apparently free from bronchial catarrh, the use of ether sets up a profuse secretion of thick tenaceous mucus which hampers breathing. This is especially the case with excessive smokers. For such persons it is well to avoid ether, or if the complication is only observed after anæsthesia is established, to substitute chloroform or the A.C.E. mixture for ether, when as a rule the inconvenience disappears.

Under ether the *muscles* at first become rigid and firmly extended, but later these conditions give place to extreme flaccidity; in some patients the muscles maintain their rigidity much longer than in others, while there is a difference in the time which muscles in various regions take to relax. Snow pointed out that although chloroform produced some degree of muscular relaxation sooner than did ether, yet the most complete flaccidity resulted when ether was used provided time was allowed for its development. I am entirely in accord with this statement. It is, I think, very common for prolonged muscular rigidity to result from asphyxial conditions, and when these are prevented or alleviated by giving inhalations of oxygen, rigidity under ether rapidly disappears. Ringer, experimenting

on muscle, found that in frogs, the vitality of involuntary muscle persisted far longer in the case of ether than in that of chloroform. Peristalsis although lessened is not abrogated, even when death is induced by ether.

The *bodily temperature* is reduced under ether, Kappeler fixes a minimum at ·3° C., and a maximum at 1·5° C. (·5°—2·7° F.). Ether increases the secretions with perhaps the exception of that of the kidneys. Elimination takes place rapidly and is mainly effected by the lungs.

Methods of Administering Ether.

Ether may be given (1) alone, or (2) in succession to other anæsthetics. The latter plan avoids the suffocating sensation caused when ether is first inhaled; it also produces anæsthesia more rapidly and without struggling.

The main indications for the successful administration of this anæsthetic are, that the air inhaled be gradually saturated with ether vapour. It cannot be too strongly insisted upon that in spite of all theoretical reasoning to the contrary, asphyxial complications and admixtures of carbonic acid gas with ether should be carefully avoided. It is best to commence the inhalation with a sufficiently dilute ether vapour so as not to excite laryngeal irritation; the vapour should not escape into the room and impregnate the air breathed by the bystanders; this can only be done by the use of one or other of the inhalers to be mentioned below.

Inhalers devised for the administration of ether by itself or in succession to other anæsthetics may be classed under the categories of (1) closed, (2) quasi open. In the first class the patient inhales ether from a bag closed from the air, and whatever air enters does so through valves

arranged with that object. The best type is Clover's portable regulating inhaler. This inhaler has been modified and improved, but in principle it remains the same. The form suggested by Dr. Probyn Williams, is probably the best as it combines a wide bore with great lightness and manageability (see p. 135). (2) In the quasi open type ether is poured upon a sponge or on an absorbent material which is surrounded by some more or less impervious substance, if it is open at the top the patient is able to breathe through the sponge containing the ether. The large mask designed by Dr. Julliard and modified by Professor Dumont of Bern is the best of these. Ether is sprinkled freely over the inner surface, the external aspect being covered with oil silk. The Allis inhaler is a nearer approach to a truly "open" method and answers its purpose well but is open to the objections common to all "open" inhalers. These are that the induction is slow and usually associated with much excitement; the patient inhales undue quantities of ether and is proportionately more liable to prejudicial after-effects, and the bystanders have to breath in an atmosphere largely contaminated with ether. The method is wasteful and has no advantages except in exceptional cases. Ormsby's inhaler is a compromise between the two classes, as in its use the patient respires through the etherised sponge into a closed bag.

Clover's portable regulating ether inhaler (fig. 22) consists, as reference to the figure indicates, of a dome-shaped ether receptacle pierced by a central shaft, into which are adapted (i.) a tube bent at right angles, which carries the indiarubber bag into this the patient breathes, and (ii.) a metal tube which serves for the attachment of the face-piece, and has the indicator attached to it. This as the ether receiver rotates indi-

commencement of an inhalation. This tolerance achieved, the ether reservoir is rotated till the indicator points to 2, and the patient then inhales, roughly speaking, half ether and half air. If this strength of vapour does not distress him, the indicator, by further rotation of the ether chamber, can, after a few seconds, be made to point to 3 (one-fourth part air, three parts ether) and then to F (full ether).

The variation in size of the pupils during ether narcosis is an uncertain guide. They are not uniformly influenced by the anæsthetic as in the case of chloroform and so have no common ground of comparison. When full anæsthesia is established the pupillary reaction to light will be less active and the size of the pupils will remain fairly constant, tending to dilate when the anæsthetic is pressed. Excessive doses produce a slowly reacting pupil and wide dilatation. The same result follows when much shock occurs with loss of blood and the anæsthetic has been given freely. Although in many instances increasing the depth of narcosis dilates the pupil and renders the light reaction sluggish, while lessening the degree of narcosis causes the pupils to contract slightly, still these phenomena are not absolutely constant; some pupils, especially in old persons, remain contracted, while others are moderately dilated and show little change. In moderate degrees of narcosis the pupils will be seen to change in size synchronously with respiration. It is never well to push the ether to a degree in which light reflex is almost abolished. The younger the eye the more active are the pupillary reactions. In testing all eye reactions it is important to avoid frequent and rough handling and to compare the two eyes, since one eye rapidly loses its reactions unless allowed to be quiescent.

With the assistance of Mr. Upcott Gill, who was my chloroform clerk, I examined a large number of patients, and the statements made above represent the conclusions at which I arrived. It may be added that as a rule the advent of cyanosis was associated with some pupillary dilatation.

The patient will, in from ninety seconds to two and a half minutes, be completely unconscious and ready for operation. The muscles are rigid at first but subsequently grow flaccid; as a rule consciousness is lost as soon as this rigidity is present, but the profound narcosis required for many operations only supervenes with muscular relaxation. Any cyanosis or respiratory embarrassment will prolong the period of rigidity. I have repeatedly produced relaxation at once by allowing the patient to inhale oxygen. Some persons require more ether to render them insensible, and those who persistently resist taking the anæsthetic by holding their breath, or by taking the shallowest breaths consistent with life, will delay the onset of unconsciousness much longer. These persons also, since they voluntarily semi-asphyxiate themselves by repressing respiratory movements, suffer great additional discomfort from the feeling of suffocation they induce.

As soon as complete anæsthesia is thoroughly established, that is when the conjunctival reflex is abolished, the indicator may be brought back to 2 by turning the ether reservoir round and there kept until the operation is over. It may be necessary in warm weather, and in the case of prolonged operations to renew ether in the receiver. This is easily done by removing the inhaler from the patient's face, loosening the stopper, and pouring in a further supply.

The patient will, during a protracted operation, require

the inhaler to be taken off his face every sixth breath or so, in order that he may take a few inspirations of air. The necessity for this will be readily recognised by any cyanosis apparent in face or ears, and by the character of the respirations and of the pulse. It should be carefully borne in mind, that the amount of an anæsthetic required to produce narcosis is much greater than is needed to maintain that condition. Also the degree of narcosis must be varied, in correspondence with the region of the body upon which operative measures are being pursued. For operations upon the abdomen, the genitals, the rectum and perineum, a deep narcosis is necessary, and must be maintained throughout the operation, otherwise movement and vomiting result. To test the degree of narcosis, although the size of the pupil is an unreliable guide, it may be noted from time to time to see whether the light reflex remains keen and the corneal reflex is returning. In deep narcosis, that is short of overdosage, the lid reflex is quite abolished, the pupil may be semi-dilated, the ocular movements sluggish and the light reflex slow. Fixation of the eyeball seldom, if ever, occurs in ether narcosis unless the ether is administered with oxygen, as in that case the depth of the narcosis may be very profound. The respiration is often hurried in light but slower and more shallow in deep narcosis while the breathing is gasping. The ruddiness of early etherisation gives place to pallor with slight duskiness after prolonged or profound etherisation. The advent of returning consciousness is commonly shown by the patient's efforts at swallowing, the initial act of the physiological mechanism of vomiting, by return of conjunctival reflex and by alteration in respiratory rhythm. Frequently also pallor with sudden pupillary dilatation may occur. In all cases it must be remembered that the dilatation of the pupils,

variations in respiration, and circulation, may be reflex and must not be mistaken for ether effects. It is this fact which convinces me that students should avoid consulting the pupil in ether narcosis until they have acquired a thorough mastery of the cycle of ether narcosis as a whole.

When it becomes necessary to anæsthetise the patient in the prone or semiprone posture, a useful addition to the Clover's regulating ether inhaler is the angular

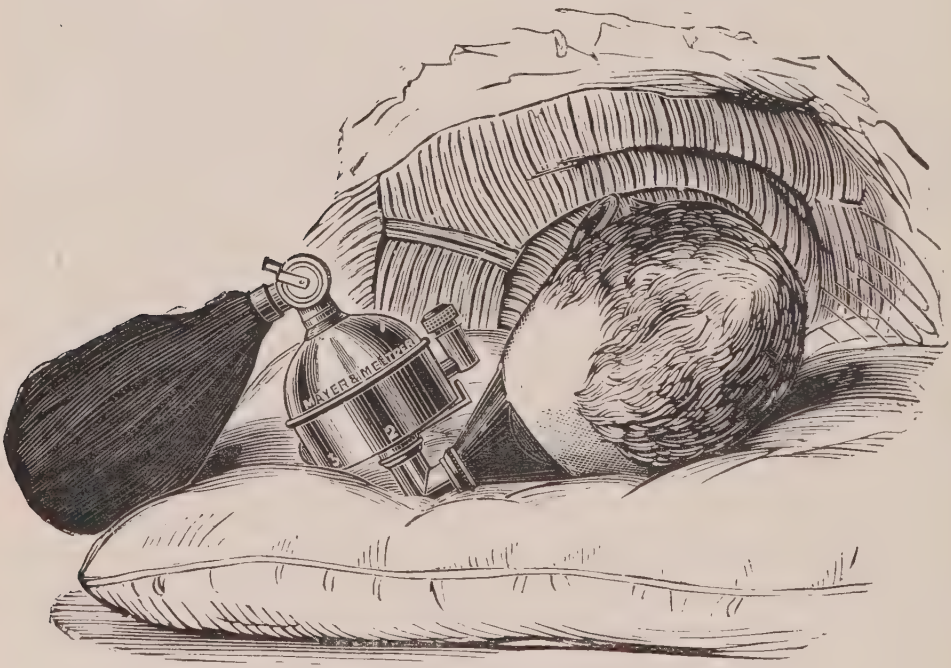


FIG. 23.—Sheppard's angular adjuster.

adjuster figured above. This useful contrivance is the invention of the late Dr. Charles Sheppard (see fig. 23).

This inhaler was intended by Mr. Clover for the administration of ether alone, but it has been adapted for the exhibition of that vapour in conjunction with nitrous oxide gas, and Mr. Clover himself writing in 1877, says, "by connecting the bag with a supply of nitrous oxide it forms a tolerably efficient substitute for the gas and ether in-

haler" (see p. 148). Thus by attaching a stopcock in the metal bent piece to which the bag is attached, gas can readily be admitted into it by a long indiarubber tube coming directly from the gas bottle.

It is often urged as an objection to Clover's regulating inhaler, that the lumen of the tube through which the

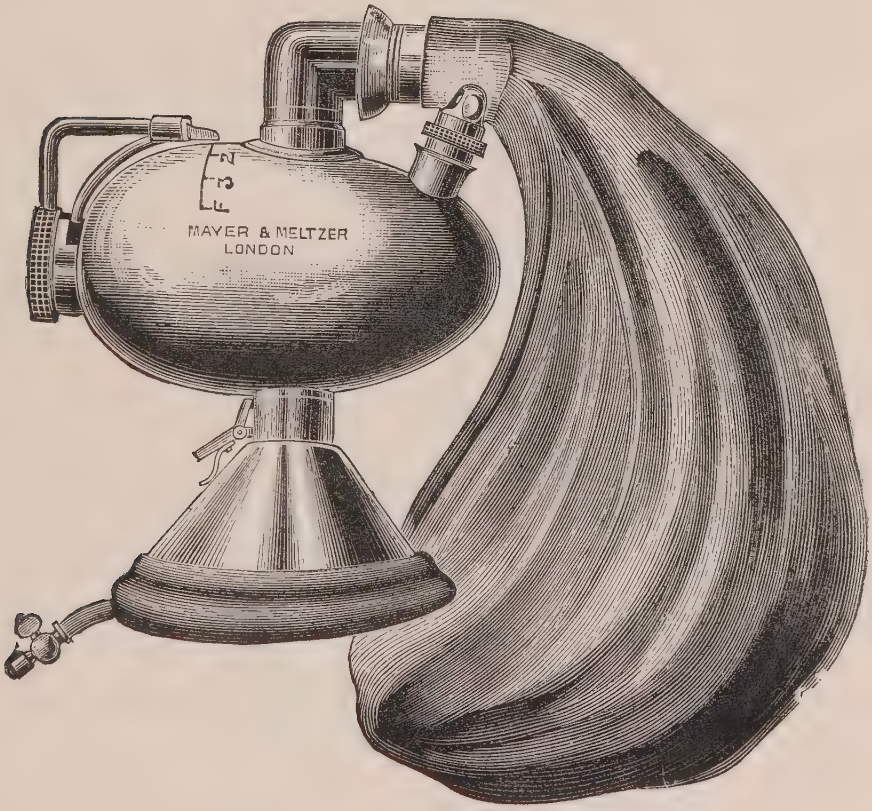


FIG. 24.—Dr. Probyn Williams' ether inhaler.

patient has to inspire is too small to permit of unembarrassed respiration. As a result the patient tends to become cyanosed and suffers from feelings of impending suffocation.* To remedy this Dr. Probyn Williams has devised a simple and light inhaler which is I think the best model yet produced. It is figured above.

* This question is fully discussed by Dr. Hewitt, *Lancet*, March 30, 1901. In this paper is described Dr. Hewitt's large bored inhaler.

This inhaler consists of an ovoid metal receiver containing the ether. It is pierced in its short diameter by a tube through which respiration takes place, and to the extremities of which are attached the face-piece and bag respectively. More or less of the respired air is deflected into the ether chamber by means of a diaphragm which works through a tube at right angles to the first. To this second tube is attached an indicator which moves on a scale marked on part of the larger end of the receiver. The inhaler has no water chamber, and being made wholly of metal can be sterilized by boiling water before use.

It will be best to pass to the semi-open method before noticing other closed ether inhalers which are used in the nitrous oxide ether sequence. Those selected for description are the Ormsby, the Rendle's mask, and the Allis' inhaler.

Ormsby's inhaler.—It consists (fig. 25) of a zinc face-piece with cushioned rim capable of being inflated through a small tube guarded with a stopcock. The face-piece is provided with a valve, which can be opened at the pleasure of the administrator; at the top of the face-piece is a cone-shaped wire cage, covered externally with red rubber and leading into a rubber bag covered by a loose net which prevents its undue expansion. In the wire cage, a sponge is placed, and upon this half-an-ounce of ether is poured. Various modifications of the inhaler are in use. Mr. Woodhouse Braine's pattern has a wider aperture between the face-piece and the cage, and has no filling tube, which he regards as unnecessary, preferring to invert the inhaler and pour the ether immediately upon the sponge. The bag also is made of red rubber which permits ether being poured into it without detriment, and is made much larger than that in the original apparatus. Dr. Hewitt has added a removable hot water chamber

which prevents the temperature of the sponge falling below zero.

In figure 26 is shown Mr. Carter Braine's modification of Ormsby's inhaler by which a succession, A.C.E., ether, chloroform, can be given. It is constructed throughout of metal, nickel-plated, all parts are easily accessible, and can be rendered aseptic by boiling. The air-valve is a

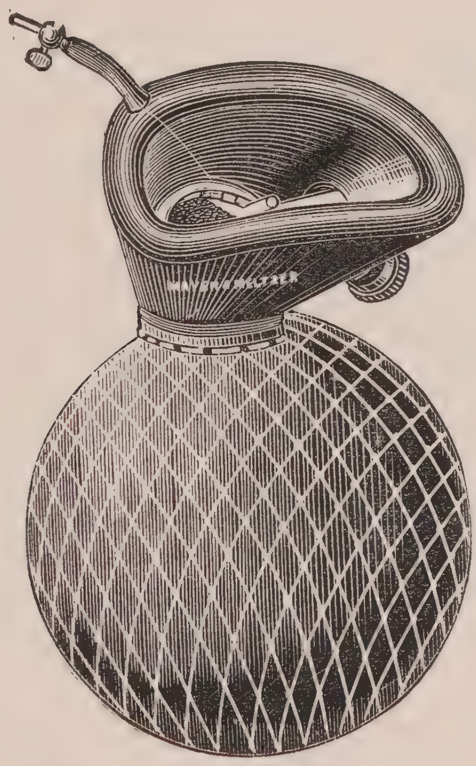


FIG. 25.—Dr. Ormsby's ether inhaler.

free one and is numbered with figures, as on Clover's inhaler. The cage being rigid and of very open work is incompressible, permits of free respiration, and cannot gradually become constricted with use. The respiratory bag is 12 inches in diameter, so that there is no need of netting. The cage bearing the sponge and respiratory bag fixes on the face-piece with a bayonet catch. An

extra dome has been constructed of metal and freely perforated with air-holes at its extremity, likewise fitting on to the face-piece with a bayonet catch and taking the place of the other dome. This attachment is very useful for the administration of the A.C.E. mixture or for ether when plenty of fresh air is necessary, as in the case of young children and of the very feeble. The administra-

FIG. 26.—Carter Braine's modified Ormsby's inhaler, the "extra dome" and the air-pad of the face-piece.

tion can be begun with the A.C.E. mixture, and then the A.C.E. dome detached when required, the other dome applied in its place and the administration continued with ether. Should it be desirable to change the anæsthetic to chloroform, the tube from a Junker's inhaler can be applied to the projecting tube of the A.C.E. dome, and the chloroform apparatus is thus complete. Should the

entry of air be too free then some of the holes at the extremity of the dome can be occluded with the hand or by packing with cotton-wool.*

METHOD OF USING ORMSBY'S INHALER.—The sponge is wrung out in warm water before use, but, if as Carter Braine suggests, an open sponge be loosely packed into the cage and only small quantities of ether are poured on at a time, this is unnecessary. The valve should be open at first and gradually closed as the larynx grows accustomed to the ether, and the inhaler should be held lightly over the face and only fitted closely as toleration of the ether becomes established. When fresh ether is required it can be either poured through the tube designed for this purpose, or as I think is preferable, thrown directly upon the sponge by removing the inhaler from the patient's face and inverting it. Care must be taken that there is no excess of the anæsthetic, which may trickle over the face. It is well to have a second sponge in readiness in case the first one freezes. The second one can conveniently be kept in warm water within reach. Unless care is taken to give the ether gradually by leaving the valve freely open at first and by putting on only small quantities of ether (half an ounce or less) at a time, the patient experiences great distress from a feeling of suffocation. This and the liability of the sponge to freeze are the two great objections to this inhaler, but as the description above shows these can to some extent be overcome by care and expertness. Another objection to it lies in the fact that a gradual increase or lessening of the quantity of ether given cannot be so well effected as in the case of Clover's inhaler.

Mr. Pechell† has adopted another plan in his use of

* See *Lancet*, December 3, 1898, p. 1,488.

† *Transactions of Society of Anæsthetists*, vol. i., p. 153.

Ormsby's inhaler. In his pattern, the bag and face-piece are connected by bayonet jointed brass collars. He removes the sponge and pours two ounces of ether into the bag and replaces the sponge. In this case the sponge does not touch the ether but simply acts as a porous diaphragm diverting the current of air from the bag. The valve cap is removed and the face-piece applied to the patient's face. When it fits accurately the valve is replaced and the patient gets ether. The strength of vapour is increased by rotating the valve cap so that its slits do not coincide. Later, the bag is tilted so that the ether soaks into the sponge and its concentration becomes increased.

The use of Ormsby's inhaler sometimes helps a patient, and relieves cyanosis when the induction of anæsthesia has been effected by Clover's method, and respiratory difficulties present themselves, the improvement is probably due to the greater quantity of fresh air admitted.

Rendle's mask (fig. 27) is a convenient pattern.

FIG. 27.—Rendle's mask and flannel cap in cone.

It is made of leather and contains a thick flannel cap which is allowed to extend beyond the lower edge and be

folded back so as to rest upon the face when the mask is applied. At its summit a sponge is placed, upon which ether is dropped in small quantities, a drachm or two from time to time. Subsequently half an ounce may be used as required. A free air-way is obtained by perforations at the summit of the cone. If the sponge freezes it must be replaced by another which should be ready at hand as in the case of the Ormsby's inhaler.

This inhaler is also made of celluloid at the recommendation of Dr. Silk, and in this form it is both handy and clean. In the use of this mask care must be taken that too much ether is not poured on, otherwise it soaks into the flannel and may drain over the patient's face. The cone is at first held an inch or so from the face and gradually brought nearer until it fits closely. It is only lifted to renew the ether or to prevent cyanosis.

Open inhalers.—The simplest form is a towel or piece of millboard rolled in the shape of a cone with a sponge placed at its summit. Ether is poured upon this and renewed from time to time. This plan is not satisfactory, and unless in exceptional cases, when there is great asthenia or collapse it is difficult to produce complete anæsthesia with it.

Allis' inhaler.—This is I think the best "open" ether inhaler; for while it can be used for chloroform, the A.C.E., or other mixture, it is always available when it is desirable to give ether largely diluted with air. I have used it for several years and have found it most valuable. It possesses the disadvantage common to all instruments of its class, that much ether is wasted, and becomes diffused through the room to the discomfort of the operator and his assistants. It consists, as can be seen from the woodcut, of a metal frame so arranged that a flannel or domett bandage can be stretched across and across. The

outside is covered with a leather case, which being prolonged below the metal serves as a well adjusting face-piece. Fresh additions of the anæsthetic are dropped from time to time upon the bandage from above. This may be done from a drop bottle, or the inhaler may be inverted and a few drachms poured in from below. Its

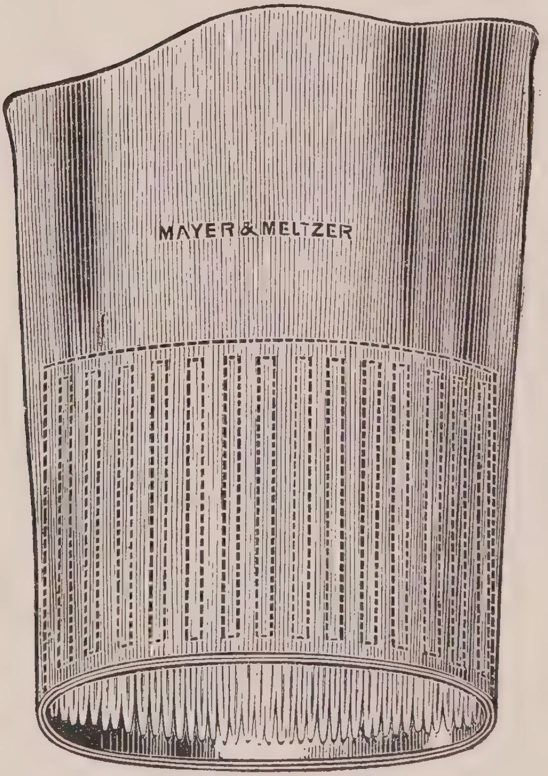


FIG. 28.—Allis' ether inhaler.
(The inhaler is represented upside down in the figure).

use needs no full description. At first a comparatively weak vapour strength should be employed, subsequently the concentration may be rapidly obtained by pouring on more ether.

The bandage must be removed and the inhaler carefully cleansed after use and a fresh bandage applied. These

inhalers can be made up of whatever size is required. The methods in use on the Continent where ether is employed are semi open in principle. Thus the Julliard-Dumont mask referred to above (see p. 128) may be taken as the type.

The Administration of Ether by itself.

The effects of ether inhalation will vary considerably according as the patient is narcotised rapidly or slowly. Slow etherisation possesses no advantages under ordinary circumstances, and is indeed positively harmful by prolonging the stage of delirious excitement. In conditions of extreme shock, or asthenia after great loss of blood, or ensuing upon a prolonged illness, it may be necessary to proceed with extreme caution and to employ small quantities of the anæsthetic, but this does not affect the general principle enunciated above.

The patient being placed in the supine position and his clothing loosened, his mouth is examined for artificial teeth or an obturator, and if such are present they are to be taken out and ether administered by one of the above methods. Although the supine position is best, yet for operations for the removal of the teeth, or upon the post-nasal space, the patient may be allowed to be propped in a sitting posture, or be seated in a chair.

When the patient first breathes ether vapour, he catches his breath, may cough, and resists the ingress of the vapour. The resistance will be in proportion to the strength of the vapour used. A few inspirations will render him dazed, the face will flush, the eyes grow suffused, and the breathing become rapid. The pulse in

this stage is large, softer than natural, and accelerated. Although stupefied, the patient can still perform certain voluntary acts, *e.g.*, putting out the tongue if loudly desired to do so. The feeling of suffocation which was at first experienced, now gives place to one of exhilaration, the dyspnœa disappears, and the respirations are full and deep. Formication and tingling are felt in the hands and feet. The pupils usually contract in this stage. The exhilaration, however, soon passes into a condition of delirious excitement. Bert denied that true excitement occurs, believing that progressive loss of muscular power supervenes. The disorderly movements commonly put down to excitement of delirium are he thought to be explained as *une sorte d'anarchie cérébrale*, the guiding centres being in abeyance. In whatever way we regard these movements, they certainly appear to be the result of temporary delusions. Thus, military men will, in this stage of etherisation, shout words of command; while those inclined to pugilism will attempt to box with the bystanders. The respirations and heart's action are considerably accelerated; the skin grows moist, the face dusky. Soon a period of quiet follows, and it should be the aim of skilled etherisation to curtail as much as possible the stage of excitement. In the succeeding quietude the limbs stiffen, the muscles grow strongly contracted and firmly set, the whole body becoming rigid. Breathing may be hampered by the rigidity of the thoracic muscles and needs careful watching at this time. Should the respirations stop it will be necessary to lift the inhaler and firmly compress the chest two or three times and so encourage respiration. The pupils dilate now and the skin becomes bedewed with perspiration, while a roseolous rash appears in patches about the neck and chest. These patches coalesce. Willett finds the ether rash to be a very uncertain phenomenon; but

after examining several hundred cases I am disposed to think it is generally present in some degree, although often so transient and slight as to be easily overlooked. The pulse resumes its normal rate, and although soft, yet remains regular and somewhat more forcible than before the anæsthetic. The blood pressure is raised by ether, but falls nearly to the normal as anæsthesia is fully established. Now ensues the stage of muscular relaxation. The patient lies absolutely insensible to all external impressions with his muscles perfectly flaccid. The lid reflex is lost. The breathing slows although it keeps quicker than normal, and is much more shallow. At this time anæsthesia may be taken as complete, and operative measures may proceed.

The depth of narcosis varies according to the amount of the anæsthetic given. For brief operations not involving a very sensitive area a light anæsthesia is to be aimed at, and in every case as little of the anæsthetic should be given as is consistent with the necessities of the surgeon. It must always be borne in mind that the severity of the after effects is dependent upon the amount of the anæsthetic inhaled, and the toleration of the patient for the anæsthetic. When once true anæsthesia is obtained the patient requires comparatively little ether to keep him insensitive.

The recovery.—The time which elapses between the moment when the inhaler is removed from the patient's face, and when he is conscious and has resumed control of his actions, varies in length in different cases. Generally speaking, the duration of this period of "recovery" is longer in proportion to the amount of the anæsthetic taken, and inversely to the physique of the patient. Some persons simply sleep off the fumes of the ether, are often a little sick and vomit some mucus or

clear fluid smelling of ether. Others become excited, going through a period of excitement similar to that which many persons experience in "going under" ether. A few, especially the neurotic, appear almost maniacal for a time. The maudlin and the jocular phases of emotion may reveal themselves and call for only passing mention. Others, especially when a severe operation has necessitated the inhalation of a large quantity of the anæsthetic, reveal a profound stage of collapse, are cold, motionless, with hurried weak breathing and feeble pulse. Certain persons commence to vomit immediately the etherisation has ceased, and continue to do so for hours with more or less frequency. All the above conditions may be slight and transient, or may need careful and suitable therapeutic treatment. No patient should be left unattended after taking ether, lest through a malposition assumed in a semi-unconscious movement his respiration become impeded and suffocation ensue. Another danger is from vomiting during recovery the vomitus filling the mouth and choking the patient. Several deaths have occurred from syncope occurring in unattended patients who have suddenly sat up during recovery. A more insidious danger during the period of recovery is chilling of the patient. Often he is removed from a heated operating theatre, or room, and carried into an improperly warmed ward, or bedroom, with the result that bronchitis or even broncho-pneumonia supervenes and this is ascribed solely to the effects of the ether or a "dirty inhaler." In all cases the patient should be carefully wrapped in blankets, hot water bottles placed in suitable positions, care being taken that their heated surfaces cannot touch and burn the skin—a not infrequent danger —and be so arranged that the head lies low, the face turned to the side. An attendant should be close at hand

to restrain undue movements, uncovering of the body, and to help in the case of sickness. Special treatment required for more grave complications and after effects are considered below.

Methods of producing anæsthesia by ether.—Irrespective of the use of particular apparatus various plans have been suggested by which a patient may become etherised without experiencing the discomforts attached to the initial inhalation of ether.

These methods are :—(1) Nitrous oxide and ether. (2) Ethyl chloride followed by ether. (3) A.C.E. solution followed by ether. (4) Chloroform followed by ether. (5) Ether with oxygen. (6) Rectal etherisation.

I. Ether in Succession to Nitrous Oxide.

(a) **Clover's method.**—This plan which at the time of its first adoption revolutionised the practice of ether narcosis and rendered ether at once a safe and satisfactory anæsthetic, is based upon the principle that the patient is able without discomfort to inhale nitrous oxide, and when unconscious ether vapour in increasing strength mixed with the gas, and finally ether vapour inhaled by itself. In this way there is no break in the continuity of the narcosis and no sudden transition. Nitrous oxide gas first, then this anæsthetic mixed with ether vapour, and finally ether vapour alone.

Many forms of apparatus have been suggested since Clover's first one was designed, but none have I think, any material advantage over the original, except perhaps those in which the bore of the air passage is enlarged. As, however, some may prefer other forms of apparatus it will be advisable to mention those most widely used.

Clover's large gas and ether inhaler.—The present form is the same in principle but has been modified and improved. It is shown in the diagrams given below. The gas supply is derived from a steel cylinder

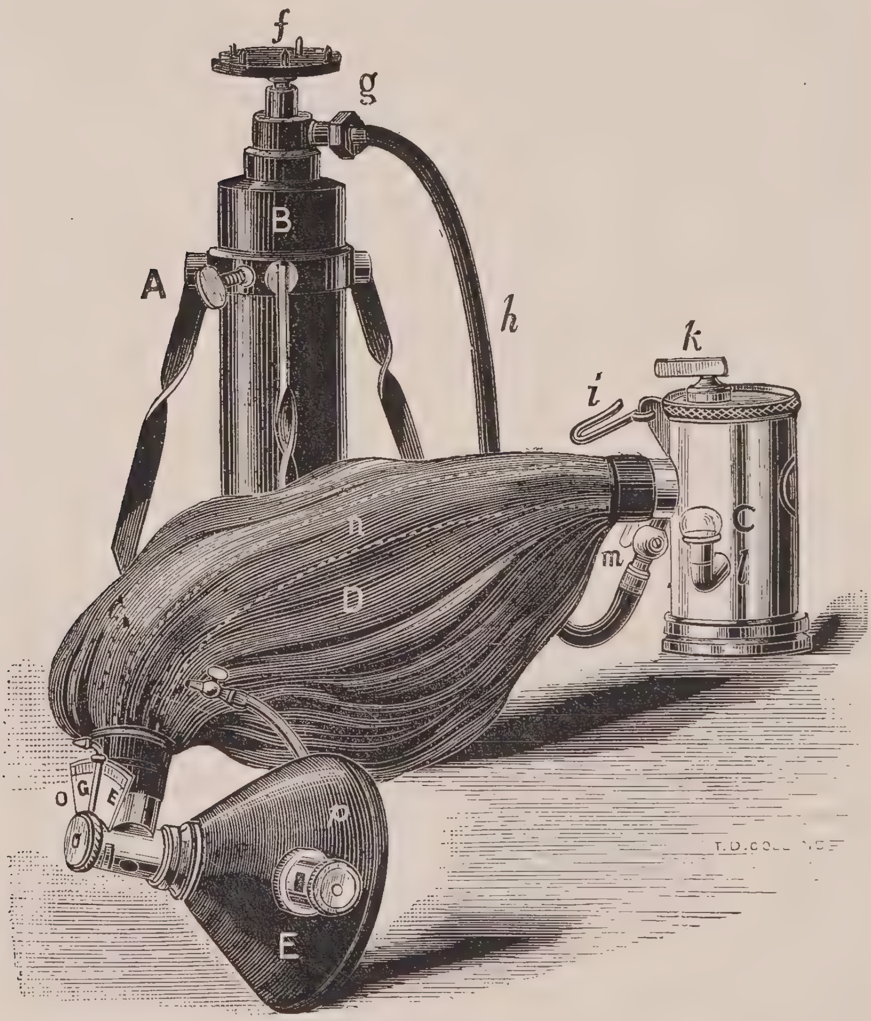


FIG. 29.—Apparatus for the administration of nitrous oxide and ether. (Clover).

(fig. 29, *B*), fixed in a tripod or placed horizontally, and the gas traverses an indiarubber tube (*h*) to the ether chamber (C). This is shown in fig. 30. The apparatus is

so arranged that gas can be given alone or with ether. By turning a tap (*k*) the gas passes directly into the receiver (*C*) containing ether, and having traversed it and passed over the surface of the ether, escapes into the face-piece (*P*) along a tube (*n*) which traverses the Cattlin's

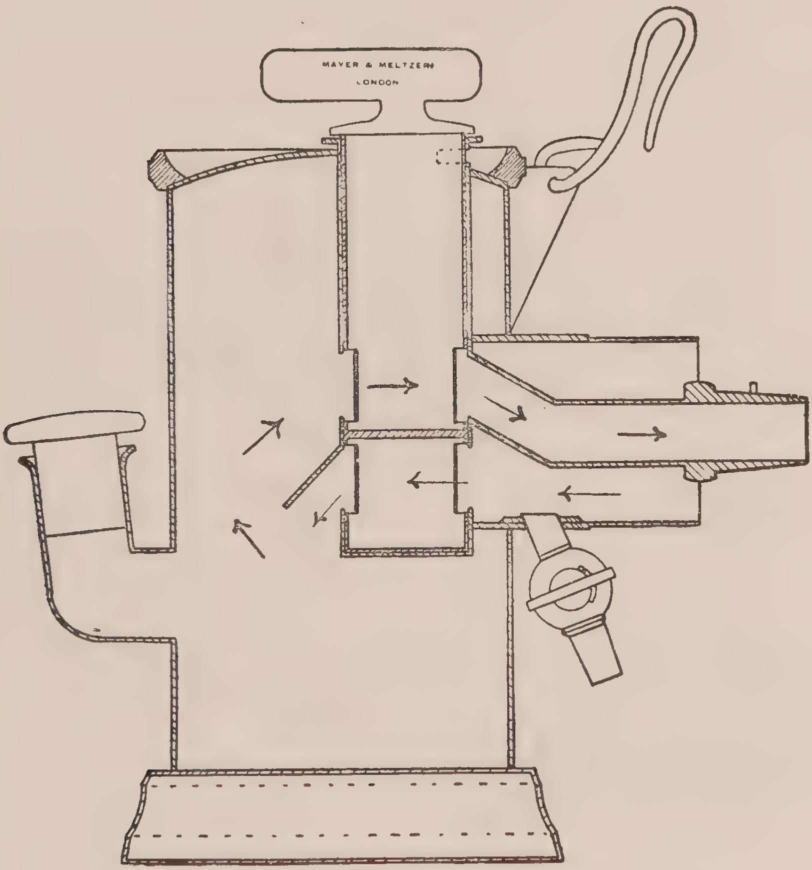


FIG. 30.—Section of ether chamber of Clover's inhaler.

bag (*D*). The amount of admixture of gas and ether is regulated by a tap (*o*), which opens the apertures of *n* and *D*. The whole apparatus is light, and is suspended by a hook (*i*) from the administrator's buttonhole.*

In this apparatus the gas supply is controlled by the

* The apparatus is made by Messrs. Mayer and Meltzer, of London.

foot, which, placed upon the foot-piece (f) rotates it from right to left to turn the gas on, and from left to right to turn it off. When the cylinders are placed horizontally, the exit valve is so situated that a foot-piece placed on the long axis of the bottle regulates the supply.

Fig. 30 shows a section of the ether chamber. The ether and gas supply taps are supposed to be open, and

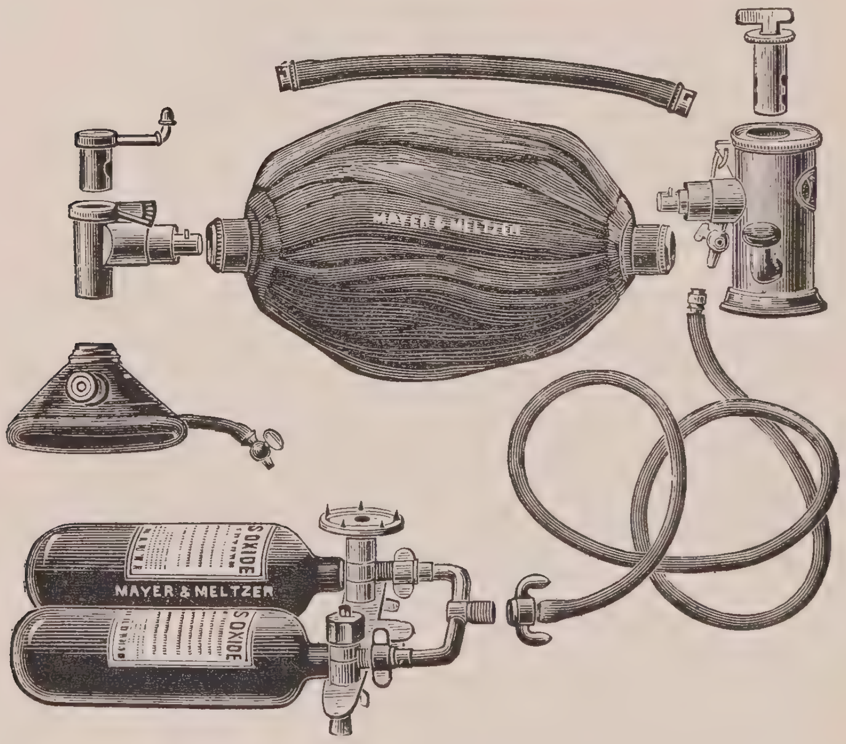


FIG. 31.—Dudley Buxton's improved ether inhaler.

the arrows indicate the route by which the mixture of the anæsthetics pass from the chamber into the central tube (n) and Cattlin's bag D.

To avoid the obvious difficulty of cleansing the older forms of the inhaler, Messrs. Mayer and Meltzer have constructed for me the apparatus figured above (fig. 31). In this all the parts are easily disconnected and the metal

parts can be boiled while the rubber portions can be carefully sterilised with carbolic acid lotion (1 in 20). A comparison of the figures will give a clearer idea of the inhaler than verbal description.

The advantages of this apparatus are :—

The absolute control the administrator possesses over the strength of vapour with which he is working; thus he can commence the administration with pure gas, then permit some gas to pass over the ether, and by degrees increase the strength of the vapour to full ether without exciting spasm or coughing.

Its great simplicity and portability. It has been termed unsightly and cumbersome, but no one familiar with its use would find it either the one or the other.

The same apparatus is equally satisfactory when ether or even nitrous oxide gas has to be administered unmixed, as with care and proper cleanliness the rubber can be kept without smell and the ether is completely cut off from the rest of the apparatus when the tap (*k*) of the ether chamber is closed.

To anæsthetise by this method the indicator is turned so as to be completely off the dial plate which is just above the face-piece. This opens the air way. The nitrous oxide tube (*h*) is then fixed to the ether chamber at *m* and the Cattlin's bag slowly filled with gas to two-thirds of its capacity. The bag should contain at least two gallons of gas. The face-piece is then applied and carefully fitted, the excess of air in the air cushion being liberated. When the patient is accustomed to the face-piece, that is in three or four respirations, the indicator is turned, during an inspiration on to the dial plate opposite the letter "G" which stands for "gas." The patient now is breathing nitrous oxide and the administrator from time to time admits more gas into the bag. When the breathing,

which at first is usually hurried and irregular, owing to the patient's nervousness, has settled into a quiet regular rhythm the tap of the ether chamber K is turned. Now the indicator is slowly moved over the dial from the letter G (gas) towards E (ether). If no check in the respiratory rhythm takes place, the ether vapour is made stronger and stronger, until on the indicator reaching E, pure ether vapour is inhaled. If, however, the breath is held or cough occurs the indicator must be put back for a respiration or so until toleration of the ether is attained. The supply of gas should be kept up to this point, but as soon as the indicator is at E the nitrous oxide is cut off by turning the foot-piece (*f*) firmly to the right, and the indiarubber tube (*h*) is detached from *m*. As soon as the patient breathes the ether freely and conjunctival reflex has grown sluggish the face-piece is lifted and the gas expelled from the bag. This may in exceptional cases be required sooner, the indication being marked cyanosis and respiratory embarrassment, or sudden pallor.

Slight cyanosis and breath holding are signs for not admitting air. If the face-piece is lifted too soon the patient will rapidly "come out" of the nitrous oxide narcosis and his blood not being sufficiently saturated with ether he will commence to struggle. On the other hand if the ventilation of the lungs by admission of air is delayed too long respiration will be seriously impeded and the heart become embarrassed. One if not more deaths have occurred through this accident although the watchful administrator can hardly overlook the obvious signs of danger, such as failure of respiration associated with deep cyanosis.

Care must be taken that the face-piece fits accurately, as if air leaks in around the air pad the patient will breathe very softly and draw the air in but get little or

no ether. When once muscular relaxation has occurred and the breathing is regular the rules given above will guide the anæsthetist, air will have to be admitted from time to time and all cyanosis carefully avoided. The tap (*m*) should be kept open in order that air may be drawn in by the patient's inspiration. When, owing to respiratory spasm, or persistent cyanosis, oxygen seems indicated

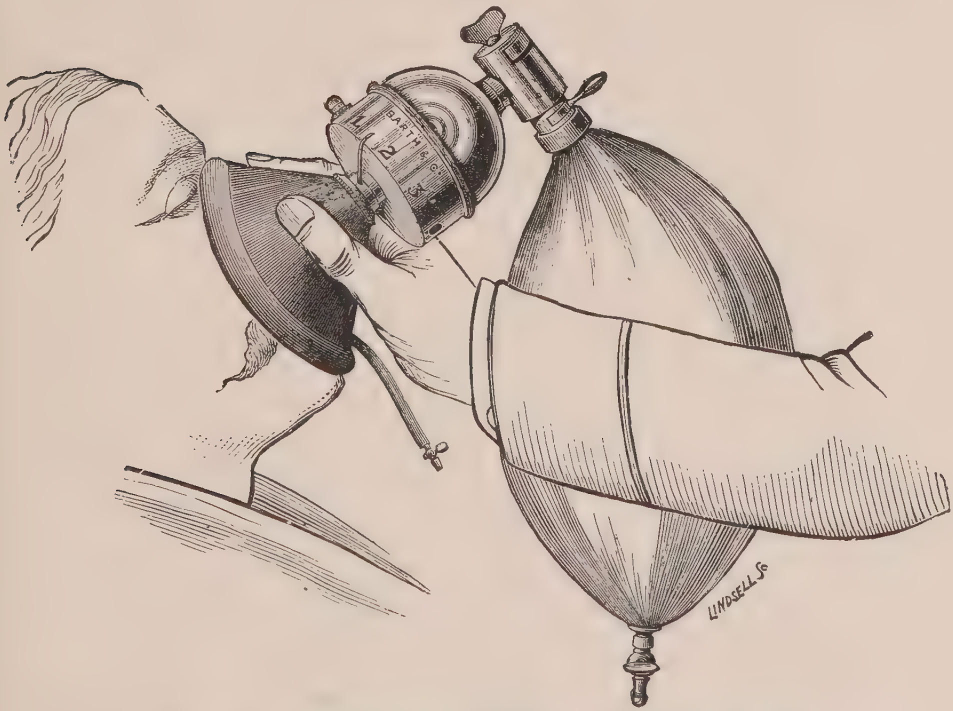


FIG. 32.—Face-piece, Clover's ether chamber, stopcock, and gas bag for the administration of nitrous oxide and ether. (Dr. Hewitt's apparatus).

it is readily given by attaching a rubber tube connected with an oxygen cylinder to the inlet at *m* when the bag D can be readily filled with this gas.

Dr. Hewitt has introduced a convenient modification of Clover's apparatus for giving gas alone, or with ether, which is figured above.

In this apparatus the inspiratory and expiratory valves are placed, not in the face-piece, but in a little chamber near it. Below this valve chamber is a two-way stopcock. The valves may be thrown into or out of action by the tap. When turned as in fig. 32, p. 153, the valves act, and all expirations (whether of air or gas as determined by the stopcock below) escape. When the tap is turned in an opposite direction, to and fro breathing (of gas or air as the case may be) results. To use the apparatus, first allow the patient to breathe air and see that the valves act freely. Then turn on nitrous oxide by moving round the handle. Should nitrous oxide unexpectedly fall short the valve action may be stopped by turning the tap, and the patient would then breathe gas into and out of the bag till anæsthesia occurs.

The apparatus is so made that a very free draught through it is permitted, the valves, which are of thin indiarubber, acting very easily and thus giving no sense of difficulty in breathing. When nitrous oxide followed by ether is required, the stopcock, &c., can be fixed to a Clover's portable apparatus as shown in fig. 32.*

The adoption of a larger aperture through which the patient breathes is an advantage, and Dr. Hewitt's most recent inhaler possesses this desideratum.†

(*b*) **Woodhouse Braine's Method.**—This plan consists essentially in keeping the nitrous oxide and the ether apparatus perfectly distinct, so that the nitrous oxide apparatus is not contaminated with the smell of ether, and patients are only aware of inhaling nitrous oxide. Full anæsthesia is induced by means of nitrous oxide gas, and then the Ormsby inhaler previously charged

* For this description I am indebted to Dr. Frederic Hewitt. See "Anæsthetics and their Administration," (1901), p. 408.

† *Ibid.*, p. 277.

with ℥iss. ether, is rapidly substituted for the gas face-piece; this is done at the end of an inspiration of gas in order that the next expiration may distend the bag of the Ormsby. No inspiration is allowed during the change of inhalers. The breath is almost invariably held for a few seconds, and then a deep inspiration is taken consisting of ether vapour, nitrous oxide and the small quantity of air always in the bag, this is quickly followed by regular inspirations and the patient passes smoothly to deep ether anæsthesia. Of the two methods I think Clover's is superior, as in it there is no break in the continuity of the induction. The patient first breathes gas, then gas impregnated with ether, and finally ether.

II. Ethyl Chloride followed by Ether.

The portability of the rapidly evaporating anæsthetics like ethyl chloride and its mixtures, renders them useful when nitrous oxide is unobtainable.

Many ways have been suggested by which the ethyl chloride may be given in sequence with ether, and reference must be made to a later chapter dealing with the anæsthetic more in detail for particulars and technique of the methods suggested.

The only essential is that complete exclusion of air is effected while the ethyl chloride is being administered.

(*a*) When separate inhalers are employed. The chloride of ethyl 3 to 5 c.c., is poured upon the inside of the mask according to the age and physique of the patient, and this is at once applied all air being excluded. In 20 to 30 seconds stertor will be heard. The mask is then rapidly changed for a Clover's ether inhaler, already filled

and arranged so that the patient at once breathes a full strength ether vapour.

(*b*) But two inhalers are not necessary. The chloride of ethyl can be poured directly into the bag of a Clover's regulating inhaler, of an Ormsby, or of that of whatever ether inhaler is selected, and the patient inspires the anæsthetic as above until stertor is heard, when the ether is turned on. Dr. Levy suggests pouring the chloride of ethyl into the ether receiver of a Clover's inhaler, and has devised a little attachment holding the requisite amount of ethyl chloride. This fits into the filling aperture. There is ample time he asserts to add ether when unconsciousness has supervened. At this point the inhaler is removed from the face and rapidly filled with ether and the induction completed.

III. A.C.E. Mixture followed by Ether.

Various plans have been suggested whereby the patient is first given the A.C.E. mixture from a Rendle's mask, cone, or other apparatus, and as soon as unconsciousness has been attained, an Ormsby's ether inhaler fully charged, is substituted for the A.C.E. apparatus, and the anæsthesia is maintained by ether. This plan answers well in certain cases in which it seems undesirable to commence the administration with nitrous oxide gas. It is important to give the mixture sparingly at first. This may be done by sprinkling it on a Schimmelbusch's mask and afterwards using a celluloid cone with a drachm or two of A.C.E. Mr. Carter Braine's apparatus (see fig. 26) answers well. The ether should be commenced before any excitement shows itself.

In the case of weakly persons and children, I have found the plan of giving A.C.E. from a Skinner's mask or Hyderabad cone and following it by ether from a Clover's ether inhaler to be satisfactory.

IV. Chloroform followed by Ether.

When nitrous oxide cannot be obtained, or is contra-indicated, this succession often proves valuable. Many persons cough in the earlier stages of etherisation, especially when pharyngeal or bronchial catarrh exists. Some patients also dread nitrous oxide and like chloroform, this is especially the case with ladies who have taken chloroform in their confinements.

Methods.—Practically any of the methods mentioned below (Chapter V.) may be employed, but patients very commonly beg for the use of a handkerchief, and there is no objection to using it with a drop bottle until the second degree of narcosis is reached, when ether can be substituted from an ether inhaler. In my own practice I usually employ a Schimmelbusch's frame for the chloroform and give the ether from a Clover's inhaler. When the ether is commenced it should not be given in unduly concentrated form, or when cyanosis is present, otherwise holding of the breath, struggling, and other undesirable phenomena will arise.

No method in which chloroform is employed is free from some risk, so that the administrator must, if he decides upon employing the A.C.E. mixture or chloroform, be fully alive to the additional danger introduced into the anæsthesia.

V. Ether with Oxygen.

I have for some years employed oxygen as an adjuvant to ether. In cases in which the induction presents unusual difficulties from dyspnœa, spasm, cough, holding of the breath, struggling associated with cyanosis; in alcoholics; and in persons of feeble vitality, the repeated filling the bag connected with the ether inhaler with oxygen removes all difficulty, and rapidly induces quiet anæsthesia. The narcosis so obtained is more profound than can be ensured when using ether by itself, as the hyperoxidation of the tissues enables more ether to enter the circulation than could otherwise occur without danger to the nervous centres, hampered as they probably would be by deoxydised blood. The plan I pursue is to admit the oxygen through a second tube fitted to the Clover's gas and ether inhaler *pari passu* with the ether, and either give the oxygen intermittently or continuously as occasion seems to demand. The oxygen certainly acts as a powerful stimulant, and is very valuable in prolonged and exhausting operations as a corrective to shock.

VI. Rectal Etherisation.

Pirogoff and Roux as early as 1847 suggested that ether should be given by the rectum, and finding that liquid ether could not with impunity be injected (Magendie), the former employed an apparatus which permitted only ether vapour to enter. He, Pirogoff, obtained such good results that he believed rectal etherisation would replace pulmonary inhalation. More recently Dr. Axel Yversen, of

with a glass intercepter devised to prevent the entrance of liquid ether into the rectum. The further end of the intercepter is joined by another and shorter tube to an anal tube. This is made for me by Messrs. Mayer and Meltzer. Some persons have employed the water at a higher temperature, but my experience leads me to believe that the untoward experiences which have been recorded have in most, if not all, cases been brought about by having the water too hot, and so permitting a too rapid evolution of ether vapour.

The usual signs of anæsthesia are present and so nothing need be said about them. As a rule children go under more rapidly than adults, when ether is given by the rectum, but the time occupied in inducing complete anæsthesia varies within wide limits. I have succeeded in 3 minutes and have had to wait 15 or 30 minutes. Dr. Stimson informs me that American surgeons have had several fatalities in employing this method. I have met with grave complications which although in part due to the physical condition of the patients, were undoubtedly not wholly independent of the irritation caused in the intestines by the entrance of ether vapour.

After effects.—Colicky pains in the intestines, urgent tenesmus, diarrhœa, sometimes dysenteric in character, painful distention of the intestinal tract with more or less severe collapse are the complications which have been recorded. Deaths have occurred.

The treatment is to be conducted upon general principles, opium forming the most useful therapeutic ally. For their prevention, the most important points needing attention, are avoidance of the method in cases with a history of past intestinal catarrh or dysenteric attacks, and great care that during the administration no liquid ether is allowed to enter the rectum.

Complications during Ether Inhalation.

The chief complications which occur during ether narcosis are connected with **respiration.** In the first place in persons whose lower jaw is underhung, this with the tongue is liable to fall back and so interfere with respiration. The fingers placed behind the angles of the mandible will readily rectify this, but it is important to see that the lower teeth are not engaged behind the upper but project well beyond them in front. The breathing may be stopped by a more serious cause through obstruction in the larynx, the rima glottidis becoming closed and no air entering the lungs. In some cases the rigidity of the masseter muscles may cause impediment to air entry by provoking tight closure of the teeth. Inspiration through the nose is very commonly imperfect through some stenotic condition, and may be greatly hindered or prevented by the nostrils being sucked in with inspiration, whilst the lips are at the same time drawn in over the clenched teeth. In this way little air can enter the chest and the patient becomes cyanosed. If the teeth be forcibly separated by a screw gag, air will enter freely and the cyanosis pass off. It is wise in these cases to insert a gag between the teeth before replacing the inhaler. A towel wrapped round the face-piece and lower portion of the face will prevent an undue entrance of air. **Laryngeal spasm,** leading to partial or complete closure of the rima glottidis may arise, being in most cases due to the impact of too concentrated ether vapour upon the sensitive laryngeal mucous membrane. It is especially liable to occur when there is pre-existing hyperæsthesia of

the mucous membrane, *e.g.*, in inflammatory conditions. Commonly the spasm is initiated by an attack of coughing, then the inspiration becomes stidulous and the patient grows cyanotic. It is usually sufficient to withdraw the ether until the spasm passes off and then administer the anæsthetic more guardedly. In very extreme cases it might be necessary to perform laryngotomy. The danger is accentuated in short thick necked persons, and in those who through inflammatory or other causes suffer from pressure upon the trachea. In one case of which I have notes, laryngotomy was actually commenced, but fortunately I was able to force oxygen into the lungs and normal respiration was restored. Chloroform was then substituted for ether. In this case there was no evidence before the ether was given to cause suspicion that it would prove an undesirable anæsthetic. The movements of respiration do not cease in the condition of laryngeal spasm, whether partial or complete. In edentulous persons the long flabby lips are sucked in and act as a kind of valve permitting expiration but hindering inspiration. To remedy this the jaws should be separated by a Fergusson's gag, it is then easy to administer the ether as the gag keeps the mouth open and the lips apart.

A more troublesome, although fortunately rare, complication occurs when the thorax becomes fixed by spasmodic contraction of the muscles of respiration. The treatment here is to maintain the air way patent, and to attempt to overcome spasm by artificial respiration. Jerking up the chin will by dragging the larynx upwards and forwards often induce the patient to take a deep inspiration. In spasmodic fixation of the thorax, abdominal respiration must be practised, and the floating ribs compressed in expiration. Stimulation of the nasal mucous membrane will sometimes initiate a deep inspira-

tion. This can be done with quills of bibulous paper soaked in sal volatile or an ammoniacal solution.

Laborde's plan of rhythmic traction upon the tongue, twenty times in a minute, will prove valuable if the above fails. Freudenthal* suggests direct irritation of the epiglottis and avers this gives better results than Laborde's plan.

When a slight degree of spasm of this kind follows coughing and irregular breathing, replacing the ether by chloroform for a few respirations will often completely remove all trouble. In all these conditions the danger is increased by the rapidly deepening cyanosis. If the air ways can be rendered patent, and this usually can be accomplished by the means mentioned above, oxygen given under pressure as from a cylinder of compressed gas will greatly facilitate recovery. Intubation and perflation with oxygen are practically always possible and seldom, if ever, fail to restore the function of respiration.

Mucus or excessive salivary secretion, by lying about the epiglottis and laryngeal chink, sometimes sets up spasm and interferes considerably with respiration. The same condition may arise from blood due to the operation or to epistaxis, and these conditions must all be borne in mind. Hæmoptysis and hæmatemesis are less liable to occur during the administration of ether than afterwards, but I have met with the former condition more than once. Placing the head well over to the side and sponging out the throat usually correct the cause and remove the dyspnœa. In persons whose faucial isthmus is narrowed, and in those whose respiration under ether is not free, the tongue is liable to grow congested, venous return being interfered with, and the swelling thus caused becomes a further factor in interfering with breathing.

* See *New York Medical Journal*, Dec. 10, 1898.

Opening the mouth, drawing the tongue forwards, and maintaining an adequate supply of air usually will remedy these difficulties.

Less important inconveniences of ether inhalation are the increased secretion from the mouth and respiratory tract; these although interfering with respiration are seldom of any great importance. Hölscher* has pointed out that râles heard in the trachea are due not to the secretion arising from irritation of the broncho-tracheal mucous membrane, but to aspiration of mucus and saliva from the mouth. It must be remembered, however, that in infants and weakly persons this excessive secretion may prove a grave complication, and cause blocking of the tubes and water-logging of the lungs. I have known one case when the secretion was so excessive that respiration stopped, and was only restored by partial inversion when a quantity of thick mucus poured from the mouth and nose, when breathing recommenced.

Coughing occurs in many persons, especially if ether vapour be given in too concentrated a form; but it is not always necessary to remove the inhaler to remedy this, for frequently while a dry cough comes on in the earlier stages of etherization, it is suppressed by pushing the anæsthetic. I have met with some cases in which cough has been very urgent and associated with inspiratory dyspnœa and cyanosis so severe as to be alarming. In such cases some spasm usually exists. Inhaling oxygen will as a rule completely and rapidly remedy this condition, or a few whiffs of chloroform may be given.

The danger of sucking foreign bodies into the air passages is of course present when the patient is under ether just as when he is under any other anæsthetic, but no detailed notice need be given here as this complication

* "Archiv. f. Klin. Chir.," B. 57, 1898.

is considered at length elsewhere. If attention, however, is paid to the posture of the patient, so that the head is turned to one side, many of the dangers just referred to may be avoided or minimised.

Over-dose.—If ether be incautiously pushed for a prolonged period, without allowing the patient from time to time to renew the air in his lungs, the respiration may stop altogether. This condition would appear to ensue upon the overloading of the blood with ether, leading to poisoning of the respiratory centre. The treatment is the immediate performance of artificial respiration. If this be properly done the blood soon becomes duly oxygenated, and the nerve centres being once more supplied with depurated blood, recover their control over the respiratory mechanism, and so natural respiration ensues. During very prolonged operations it is also wise to give ether sparingly during the last portion of the time, as when once the patient has been thoroughly saturated with the anæsthetic he will remain unconscious for a considerable time without further inhalation. When care is taken to avoid the patient growing at all cyanosed over-dosage cannot occur. Some fatal results have followed the practice of holding an inhaler firmly over the patient's face and neglecting to allow him to breath air from time to time.

Rarely, the **heart** may give trouble. In a few recorded cases fatal syncope has occurred at the commencement of ether inhalation, but whether such casualties can be justly imputed solely to ether influence, is I think doubtful. If the patient struggles violently, as he is sure to do if the ether is given in too concentrated a vapour, he is liable to syncope from the strain imposed upon his heart.

Vomiting during the operation is nearly always due to the giving of too little ether, and follows upon the

partial resumption of consciousness. The patient will be observed to inspire irregularly with shallow breaths, followed now and again by yawning inspirations. This will be succeeded by efforts at swallowing, rapid and chiefly abdominal inspirations ensue, and the patient retches and vomits. Conjunctival reflex returns just before the sickness. In treatment two indications are now paramount, to get rid of the vomited matter and to avoid any of it being drawn into the larynx by the deep inspiration which always follows the act of vomiting; secondly, to prevent complete return to consciousness. To obviate these the patient's head should be turned to one side without being raised and all vomit removed with a sponge or by the finger; the inhaler should be then rapidly re-applied, and if further vomiting occur recourse must be had to similar manœuvres. But a judicious pushing of the anæsthetic at the first signs of the onset of vomiting will often, if not always, prevent the occurrence of sickness. In carrying out this plan great care must be taken, lest if it fail and vomiting occur, the ejected matter should enter the windpipe. If vomit be drawn into the trachea and cannot be coughed up, it may be necessary to open that tube and take measures for the removal of the foreign bodies from the air passage. Aspiration of gastric and intestinal contents in cases of abdominal distension is liable to occur during anæsthesia. Many of the recorded deaths under ether have arisen from this cause, and the greatest care must be taken to avoid the complication by lavage, when that is possible and expedient, or by maintaining a sufficiently light anæsthesia to ensure laryngeal reflex persisting. The subject is, however, dealt with elsewhere and at greater length.

Ether tremor.—Occasionally patients during the induction of anæsthesia and even when completely anæs-

thetised evince this curious and inconvenient symptom. One or both legs shake and tremble, sometimes with great violence. If any attempt is made to control the movements a clonus is set up and the condition made worse. The complication is not common but I have met with it not infrequently. It is sometimes possible to overcome it by deepening the narcosis or by changing the anæsthetic for chloroform.

After Effects of Ether.

These are immediate and remote. Ether chills the body, so that when the anæsthesia has to be kept up for any length of time it is advisable to keep the patient well covered up, and to apply hot water bottles to feet, thighs and flanks. The arms and legs may also be bound up in cotton wool, especially when rectal etherisation is contemplated. It has been suggested that the use of a hot water table for prolonged and grave operations would counteract the shock.

The unpleasant taste and smell of ether often hangs about a patient for hours. It is best got rid of by fresh air in warm and well heated rooms in cold weather. The clothes should be changed and the mouth washed out with a solution of chlorate of potash or other mouth wash. Whenever practicable a patient should be removed from the room in which the anæsthetic has been given as soon as the operation is completed.

The **dangers of ether** when **immediate** are due to :—

1. Interference with respiration.
2. Interference with circulation.
3. The occurrence of vomiting.

When **remote** arise from :—

1. Inflammatory attacks affecting the mucous and serous membranes of the respiratory tract and pleuræ.
2. Failure of the circulation.
3. Rupture of vessels.
4. Renal complications.
5. Gastro-intestinal tract. Vomiting.

Immediate After Effects.

1. **Respiratory.**—Dyspnœa may arise from the posture in which the patient is placed after being put back to bed. Care should always be taken that the head is so arranged that respiration is not interfered with. Also, it must be borne in mind that vomiting may occur and someone should be at hand to prevent suffocation from aspiration of vomited matter into the trachea. An accumulation of mucus may hamper respiration after ether, for until the patient is sufficiently come round he will be unable to cough away the cause of obstruction. Hæmoptysis rarely occurs, but I have seen slight cases on several occasions.

2. **Circulatory.**—Slight faintness may ensue after lifting the patient back to bed, but I have seldom seen trouble from this cause. In no case must the patient be allowed to sit up for some time after the senses have returned, as fatal syncope has occurred upon the patient sitting up to vomit.

3. **Vomiting** commonly sets in before the patient is fully conscious, but as a rule is slight and soon passes off. When placed in bed he should have his head turned to

one side. It is exceptional for a patient to vomit more than twice unless food has been taken too soon after the anæsthetic, or the patient has been imperfectly prepared for the operation.

Remote After Effects.

A catarrhal condition of the air passages, of the gastro-intestinal tract, and of the renal mucous membrane are the most serious of these.

1. **Respiratory.**—In a certain number of cases such complications occur, but I believe when ether is properly given it is rare to find bronchitis, broncho-pneumonia (so-called ether-pneumonia) following its administration. It has been pointed out that pulmonary complications are most commonly found to arise in cases of abdominal section and especially when septic conditions exist. In this statement probably lies the explanation of the occurrence of many cases of the so-called ether-pneumonia. The infection of the lungs is, according to many observers, due to the aspiration of septic material from the abdomen which has found its way into the air passages. Hölscher's experiments referred to above show that aspiration from the mouth, where the pneumococcus is commonly found, can, quite independently of ether, introduce mucus and saliva into the trachea and bronchi. Whatever be the true pathogenesis of lung complications following ether inhalation, two facts are certain. Firstly, broncho-pneumonia does occur, although much more rarely than is commonly believed, and secondly, complications are less liable to be produced when the anæsthetist limits the quantity of ether given and avoids super-saturation of the

blood. In times before anæsthetics were employed, it must be borne in mind, pneumonia was a comparatively common complication of operations. And further, as ether is usually selected for the most desperate cases it would probably be used when pneumonia is most likely to develop.

Bronchial catarrh is a not infrequent after-effect. I have met with a case of pleurisy with pleuro-pneumonia, but as the condition was right sided and occurred subsequently to an operation for the relief of hepatic abscess it may not have been due to ether. Bronchitis is especially liable to be caused in patients who have suffered from the disease previously, and seldom in my experience starts from ether chilling unless in the aged and asthenic. The danger of broncho-pneumonia and of true lobar pneumonia after ether is one about the frequency of which it is difficult to decide. I have repeatedly been told of cases of ether pneumonia which upon investigation I have found to be merely bronchial catarrh, without any of the clinical aspects of the graver lesions. On the other hand, Dr. Drummond,* Dr. McCardie and others, have published cases of pneumonia which apparently were due to prolonged etherisation. In a valuable discussion (see *Transactions of Society of Anæsthetists*, vol. iii., pp. 55 and 69) this subject was carefully considered, the consensus of opinion being that true pneumonia is a rare complication of ether inhalation, provided the method adopted is one which prevents excessive quantities of the anæsthetic being inhaled. The association of pneumonia after ether with abdominal surgery is obviously one of importance, as the patients in these cases are at once liable to be auto-infective, and to be placed in an unfavourable condition as regards pulmonary ventilation. If there is much

* *British Medical Journal*, 1898, vol. ii., p. 939.

bronchial secretion and the abdomen is tightly bandaged so that respiratory movements are limited the secretion cannot be got rid of and is extremely liable to act as a local irritant. It is, no doubt, this which in prolonged etherisation, especially when the anæsthetic is given freely, causes pulmonary trouble after ether. I am bound to say that in my own practice I have seen very few really severe pulmonary sequelæ to etherisation, but I have always in prolonged operations restricted the quantity of ether employed, and usually, when the condition of the patient permitted it, changed the anæsthetic to chloroform after half an hour or so.

This precaution is especially needful if the patient shows signs of free bronchial secretion. It is a significant fact that most pulmonary sequelæ of ether occur among hospital patients. Pneumonia seldom follows the inhalation of chloroform as a recent writer has pointed out, but bronchitis certainly occurs as an after-effect. But even admitting this statement, which probably no experienced anæsthetist will dispute, we are still left with the equally well authenticated fact that when the patient who has taken ether for a prolonged period is kept free from chills he seldom if ever suffers from pneumonia. As a practical outcome of the discussion it may be accepted that pneumonia is always a possible although rare after-effect of ether and this liability must be reckoned with in making the choice of the anæsthetic and of the method of giving it. When the condition of the patient suggests pulmonory susceptibility ether had better be avoided.

Another aspect of this subject is the infection of the patient by septic organisms from an ether inhaler. The possibility cannot be doubted when dirty instruments are used. Ether, however, is not favourable to the existence of pathogenetic organisms. When an inhaler such

as that figured on p. 150 is used and the parts boiled or sterilised in carbolic acid solution this source of danger can be absolutely removed.

Although the treatment of these lung complications does not fall within the scope of this book, something may be said about prophylaxis. Bearing in mind that there is always a fall of some degrees of body temperature upon taking an anæsthetic, it is most important that the patient should be warmly clad and that the room in which he is operated upon be kept at a proper temperature. Not less necessary is it that after the operation he should be always well covered up and carried into a room also heated, and care be taken that he is not chilled during the passage from one room to the other. Many persons lose their lives for want of this obvious precaution.

One of the gravest complications in ether narcosis is a spasmodic condition affecting the respiratory tract. Fortunately it is comparatively rare. It is not always associated with closure of the glottis, although the air passage is probably narrowed. The patient's respiration becomes shallow and cyanosis rapidly develops. This usually occurs after a paroxysm of coughing, and is not associated with an "overdose" nor with a suddenly increased strength of vapour. The onset may be early in narcosis or after the patient is completely anæsthetised. There are no signs of dyspnœa such as violent respiratory efforts but merely fixation of the chest with cessation of the function of respiration. I have met with the condition in short necked stout persons and regard it as a vagal reflex. It is almost impossible to perform artificial respiration by the usual methods owing to the fixation of the thorax, but compression of the abdomen and rhythmic traction upon the tongue while oxygen under pressure is introduced into the lungs will counteract the spasm. Failing these

measures the larynx would have to be opened, but I have fortunately never seen the necessity for this.

Profuse bronchial secretion, especially if the mucus is thick and tenacious, may cause trouble. In slight cases sponging the fauces and discontinuing the ether will be all that is required. In extreme cases when the lungs appear to be waterlogged inversion and rhythmic traction upon the tongue will provoke a flow of mucus from the mouth and clear the lungs. The possibility of an acute œdema in such cases must be remembered.

2. **Circulatory.—Ether collapse.**—After a very prolonged administration of ether, when large quantities are used, the patient may become dusky, the respirations shallow, the extremities cold and the circulation poor. Especially is this liable to occur when the operation has been severe. Shock so arising, whether due to over-dosage with the anæsthetic, or to this coupled with surgical shock, is best treated by the feet-raised position, heat applied over the body and a sinapism on the pre-cordium.

Syncope or **faintness** following ether inhalation except as a concomitant of "collapse," or unless arising from persistent vomiting (*vide infra*) is very unusual and only occurs in my experience in the case of persons pre-disposed to syncope.

3. **Hæmorrhage** into the brain or medulla has been noted as a result of rupture of an artery after ether inhalation. It is not easy in such cases to eliminate coincidence, but cerebral hæmorrhage has certainly been found post mortem in cases of death under ether. On two occasions I have known this accident to happen to patients for whom I was to have given ether, but who died from the hæmorrhage a day or two before the operation was arranged, and of course before any anæsthetic

was given. Had the hæmorrhage occurred during the etherisation the natural inference would have been drawn that it was the result of the ether inhalation.

4. **Renal complication.**—As has been pointed out above, the most conflicting evidence has been advanced about the effects of ether upon the renal mucous membrane. Clinically many observers have noted more or less severe nephritis, hæmaturia, diminution and even suppression of urine following the use of ether. Albuminuria not infrequently follows its use and when existent before the ether is taken it is commonly increased after the administration. My own experience is that when ether is carefully given renal complications are very exceptional, even albuminuria is unusual and suppression of urine most rare. I have used ether when it was known that kidney disease existed without untoward results following the inhalation. Still many careful observers have found such complications, and it would appear better to avoid the risk if there is no very cogent reason for the use of ether in the case.

5. **Gastro-intestinal tract.**

Nausea and **vomiting** in some cases may prove troublesome and very intractable. They usually occur in persons whose general health has been impaired before taking the anæsthetic. All food and stimulants must be withheld for three or four hours after ether, and the patient be encouraged to take teaspoonfuls of *hot water;* tepid water provokes more vomiting, hot water checks it. The use of metal spoons in so administering the water should be avoided that the lips and tongue may not be blistered. I have found that when sipping hot water fails, a copious draught of it will often succeed. In some cases iced soda-water in sips is useful, while iced black coffee with a dose of bromide of sodium or ammonium is

often efficacious (gr. x. to a small cupful). Absolute quiet with an enforcement of the supine position must be observed, the patient being placed in an airy room, with windows open, if the weather permit it. He should be well covered with blankets or rugs. In lesser degrees of sickness, sucking pieces of ice is useful; but the loading of the stomach with ice-cold water is a measure often followed by great sickness and discomfort. Covering the face with a thin handkerchief on which is dropped toilet vinegar will frequently check the tendency to sickness. Mackenrodt suggests cider vinegar used in this manner.

Should vomiting continue and there be accompanying collapse, iced dry champagne may be given in teaspoonful doses every quarter of an hour until improvement occurs. A mustard leaf over the pit of the stomach will often prove beneficial. In persistent vomiting Kussmaul's method of lavage is recommended by Rhoades.* He introduces an Ewald's tube and syphons in and out with boric acid lotion (gr. v. to ℥i). When vomiting is feared rectal feeding for forty-eight hours should be adopted.

Some persons suffer from great nausea without much sickness. Small doses of tincture of nux vomica will do good in these cases, one minim in a teaspoonful of water, by preference hot, may be taken every ten minutes for an hour. This will usually check the nausea, and failing it, Dr. Ringer's suggestion of drop doses of vinum ipecacuanhæ may be tried. Dilute hydrocyanic acid in minim doses is also useful. Hæmatemesis has been recorded as having followed the use of ether, I have never met with a case of this.

Hiccough, which is sometimes very severe after ether, may be cured by mustard (ʒj. infused and added to ℥iv. of boiling water), taken in sips. Less unpleasant remedies

* *Therapeutic Gazette*, Oct., 1897.

are oil of cajeput, chloral, and morphine (administered hypodermically). A small cup of strong green tea, taken hot and without sugar or milk, will often check hiccough. The thirst, sometimes a troublesome result of ether inhalation, will frequently disappear if rectal injections of hot water are given.

Diarrhœa and passage of blood per anum after rectal etherisation should be treated by emollient injections containing opium, while the general strength of the patient should be attended to, and his collapse treated upon general principles.

Deaths during Ether Narcosis.

In the *Lancet* Report * seventy-nine deaths are quoted and particulars of the cases are given. The causes assigned may be summarised :—

Imperfect anæsthesia producing shock.—Asphyxia from blood, vomit, or regurgitated intestinal contents entering the trachea; respiratory spasm; bronchorrhœa.

Cerebral apoplexy in a case of senile degeneration of the arteries, embolism, "heart failure," "paralysis of the heart," heart failure during stage of excitement with struggling.

Pulmonary conditions.—Bronchitis in an emphysematous patient, congestion of the lungs, pleurisy with effusion, pneumonia, pulmonary œdema, diphtheritic laryngitis, and emphysema.

Renal conditions.—Uræmia, "from pre-existing kidney disease."

The autopsy in these cases shows the most common

* *Op. cit.*, p. 165.

N

lesions to have been chronic disease of the lungs (mainly emphysema), of the kidneys, and of the heart. In several cases death resulted from mechanical asphyxia; one, a case of goitre, one with undigested food wedged behind the larynx, and several of fæcal material in the lungs in patients suffering from intestinal obstruction. In another, an ether adapted only for local anæsthesia was inhaled with a fatal result. As would be expected, many of the deaths attributed to ether were those of patients who were *in extremis* at the time of the operation, and for whom ether was selected in order to supply some stimulus in their profoundly collapsed state. There is very little doubt that none of the cases reported were deaths from overdosing with ether. There were several in which anæsthesia was clearly never obtained and death from shock took place; while in most of the cases the choice of the anæsthetic appears not to have been a good one. In pre-existing respiratory embarrassment (*e.g.*, goitre), in chronic lung disease, in advanced renal disease, and when the arteries are old and rigid, the use of ether may easily produce fatal results such as are mentioned in the Report above cited. In the Report of the British Medical Association* four deaths are recorded as definitely associated with the anæsthetic, and two more or less certainly classified. These were due in two cases to aspiration of stercoraceous material. In the third case syncope occurred in a feeble anæmic woman lying on her left side. The heart failure occurred as the kidney was being manipulated, and was coincident with vomiting. The fourth case was that of a man who was in an extremely grave condition and died before the commencement of the operation. Cerebral hæmorrhage and uræmia occurred respectively in the remaining two cases, and several days subsequent to the

* *Op. cit.*, pp. 61 and 64

administration of the ether. Most of the deaths recorded by Gultz, in his statistics of deaths under anæsthesia in Germany, were attributed to pneumonia, but as has been pointed out many of the fatalities were the result of auto-infection, and others were due to the injudicious methods adopted by which excessive quantities of ether vapour flooded the lungs for prolonged periods.

CHAPTER V.

CHLOROFORM.

Chloroform ($CHCl_3$), trichloro-methane, methenyl trichloride, as employed for purposes of anæsthesia, is a fluid "to which has been added sufficient absolute alcohol to produce a liquid having a specific gravity of not less than 1·490, and not more than 1·495" (B.P.).

Chemical and physical properties.—It is a colourless limpid heavy liquid with a specific gravity of 1·497 at 62·5° F. (17° C.) (Regnaulst); vapour density 4·199 (Dumas). It has an agreeable ethereal odour and sweet taste. Its vapour is not combustible, but if mixed with alcohol and ignited it burns with a smoky flame having a greenish edge. It is very volatile, but although mixing freely with air, pure chloroform vapour can only exist at a temperature of 140° to 143·6° F. (60° to 62° C.). Thorpe gives the boiling point as 61·2 C. and its density at 0° C. as 1·5266 compared with water at the same temperature (Allen). When exposed for some time to light, chloroform splits up into chlorine and hydrochloric acid. Chloroform vapour diffused in a hot room when illuminating gas or an open fire is burning decomposes, and suffocating fumes are liberated. I have noticed that this decomposition occurs when a powerful electric lamp is held over the chloroform inhaler. These fumes are composed of carbon oxychloride, $COCl_2$ (phosgene gas), and are always formed when chloroform is decomposed by light or heat in the presence of moisture. To test paper chloroform should be absolutely

neutral. It is almost insoluble in water. It mixes freely with ether, absolute alcohol, petroleum spirit, and benzine.

Chloroform is prepared in several ways. (1) By distilling dilute ethylic alcohol with calcium hypochlorite (bleaching powder) in the presence of calcium hydrate (slaked lime). After distillation the impure product is carefully purified. The safety of the chloroform finally obtained depends largely upon the accuracy with which this is performed. Raoul Pictet has effected purification by fractional crystallisation between $-80°$ and $-82°$ C., but his method is probably less effectual than that of distillation.

Chloroform may also be manufactured from (2) methylated spirit (wood spirit); the product when carefully purified is said to be chemically indistinguishable from that obtained from rectified spirit. Methylated spirit is, according to Allen,* more difficult to purify and more liable, unless very carefully prepared, to contain by-products, such as chlorinated oil, &c. If, however, it fulfils the tests given below, it is in every way satisfactory.

(3) A further source of chloroform is acetone, prepared by the dry distillation of acetate of lime. Other processes exist by which chloroform is produced, but no description of these appears necessary in this place.

It is stated by some that chloroform possesses a slightly varying physiological action according as it is derived from one or the other source detailed above. In chloroform prepared from alcohol there is, according to Dr. J. Wade and Mr. H. Finnimore,† a small amount of ethyl chloride, and this accelerates anæsthesia. In acetone

* "Commercial Organic Analysis," p. 235.

† *Journal of Chemical Society*, July 1904, p. 938. See also *Trans. Soc. Anæsth.*, vol. vii., p. 89, where it is stated that the addition of 0·25 per cent. of ethyl chloride to acetone chloroform renders it physiologically identical with alcohol chloroform.

chloroform there is no ethyl chloride, and Mr. Powell has found its absence protracts the induction period.

Dr. F. W. Tunnicliffe* has made some careful experiments with chloroform and chloroform residues to test whether their toxicity becomes increased, as a result of keeping, transport, etc. The specimens examined were taken out to South Africa and subsequently sent to England, where the examination took place. The conclusion arrived at was that when the chloroform is initially pure, except for the added alcohol, it remains free from pharmacological deterioration under the ordinary conditions of military transport. This of course assumes that the bottles which contain the chloroform are kept closely stoppered and protected from a strong light.

Chloroform is liable to contain certain impurities.—*Alcohol*—This must be present in a small quantity in order to prevent decomposition of the chloroform. The impurity is detected firstly by the specific gravity; when this is below 1·49 adulteration by alcohol is probable.

The following tests should be satisfactory:—

1. The sample must have the characteristic appearance, smell, and taste, of pure chloroform.

2. Specific gravity should be 1·49 and the boiling point 60·8° C. (boiling point above 61·2° usually points to butyl and amyl compounds).

3. Water, which has been shaken for five minutes with half its volume of chloroform, and separated from the chloroform, should be neutral to litmus (absence of acid), should not afford any colour with one c.c. of solution of cadmium iodide and two drops of mucilage of starch (absence of free chlorine), and should not yield more than a very slight opalescence with four drops of solution of nitrate of silver (absence of chlorides). After shaking sulphuric

* *Journal of the Royal Army Medical Corps*, vol. ii., No. 4, p. 459.

acid with ten times its volume of chloroform for twenty minutes and setting aside for fifteen minutes, both the acid and the chloroform should be perfectly transparent and nearly colourless. Two c.c. taken from the layer of sulphuric acid, and diluted with five c.c. of water, should remain transparent and nearly colourless, and should have a pleasant odour. When this liquid is further diluted with ten c.c. of water, and stirred with a glass rod, it should still be transparent and colourless, and the addition of four drops of solution of silver nitrate should not cause more than a slightly diminished transparency. Water which has been shaken with half its volume of chloroform previously treated with sulphuric acid as described above should not afford more than a slightly diminished transparency with solution of silver nitrate ("British Pharmacopœia," 1898).

Hydrochloric acid and *chlorine* are liable to be developed if chloroform be exposed to light and air. The first gives an acid reaction; the last has a characteristic irritating odour, and bleaches. According to Sir William Ramsay, when chloroform is kept over slaked lime and decanted off before use it is kept pure. On the other hand, Mr. David Brown* asserts that contact with lime causes a rapid decomposition of chloroform. The addition of alcohol one per cent. will, M. J. Regnauld believes, keep chloroform pure even if left exposed, and Mr. Brown appears to entertain this view, as he says:—"It is also my experience that 1·497 chloroform is not the delicate article some people imagine, but that it may be exposed to sunlight for some weeks without undergoing change."

* *Pharmaceutical Journal*, Dec. 14, 1898.

Physiological Action of Chloroform.

Harley pointed out that chloroform destroys the red corpuscles of blood. This may possibly, he thinks, explain the occasional supervention of jaundice after chloroform narcosis. I examined the blood in a large number of cases before and after the patients had taken chloroform, and found both a lessening of the number of red corpuscles and an actual increase in the number of white corpuscles. However, many other factors such as restriction of diet and loss of blood probably play some part in bringing about the result. It has been shown by Moore and Roaf,* that hæmoglobin and serum proteid, and by Vernon Harcourt and Victor Horsley,† that the corpuscles, so long as they maintain their morphological integrity, possess the property of retaining chloroform in the blood and are thus the active agents in conveying it to the tissues of the body.

Upon the blood corpuscles out of the body chloroform certainly acts as a solvent. It is a protoplasm poison rapidly destroying the contractility of muscle and the irritability of nerve tissues.

Prolonged inhalation of chloroform repeated day after day for a considerable time is said to lead to fatty degeneration of the tissues, and it is further asserted that like changes occur in a less marked degree even when but little of the narcotic is taken. Changes in the liver resembling those seen in acute atrophy of that viscus, and swelling with subsequent destruction of the epithelium lining the tubules in the kidneys have been

* *Proc. Roy. Soc.*, vol. 73, p. 382.
† *Brit. Med. Journal*, July 23, 1904.

recorded. How far such destructive changes are due to absorption of excessive quantities of the anæsthetic, there is as yet no evidence to prove.

Upon the skin and abraded surfaces: chloroform benumbs and acts as a strong irritant, and if evaporation of the condensed vapour be prevented vesication follows.

The various parts of the nervous system appear to become affected in the same order as obtains in the case of ether, the cerebral centres are influenced before the sensory fibres of the cord, these before the motor fibres, while last of all the medulla oblongata becomes paralysed.

Chloroform has been believed to possess a selective action upon the nervous system, analysis of the tissues of persons who have been killed by chloroform showing that the brain and cord contain proportionately more of it than other tissues (Lallemand, Perrin, and Duroy). Julius Pohl has also found that the brain of narcotised subjects contains more chloroform than the blood contained in the afferent blood vessels. What is the nature of the action upon the nerve centres we are unable to say, but evidence points to the probability that it is exerted upon the tissues themselves. Hamilton Wright * has shown that the neurons are profoundly affected by both chloroform and ether, and the effect is proportionate to the duration of the inhalation. Marked although evanescent microscopic changes occur with rarefaction of the cell-substance which it is suggested may modify nervous function. The effects of anæsthetics upon isolated nerve have been carefully worked out by Waller. This observer has shown that, in the case of chloroform, the nerve tissue readily loses its electro-excitability, seven times more easily than in the case of ether, and is liable to be so permanently damaged as to lose it entirely.

* *J. Phys.*, vol. 26, pp. 30 and 362.

It has been shown by Sherrington and Sowton, and by others, that chloroform exercises a direct influence upon all muscular tissues, although voluntary is less affected than involuntary muscle. The action is proportionate to the strength of the chloroform vapour.

Chloroform, although possibly in part split up (Zeller), certainly remains mostly unchanged in the body and is eliminated in the urine, the breath, and the milk.

Physiological Effects of the Inhalation of Chloroform.

The effects produced vary considerably, according as weak or strong vapours are inspired. When two per cent. is inhaled the ordinary phenomena of anæsthesia occur, while stronger vapours produce death by the direct action of the chloroform upon the tissues. Dealing firstly with the physiological effects of dilute vapours, it is convenient to divide the period of narcosis into five degrees. The last two degrees, however, require stronger vapours.

In the first degree—from commencement of inhalation to the impairment of consciousness—fulness in the head, ringing, buzzing in the ears, palpitation of the heart, are sometimes felt; there is also some diminution of common sensation. The respiration is hurried, especially when the patient is nervous. The circulation is accelerated and the pulse may be at first fuller, but soon grows weaker. The pupils are sensitive to light and are moderately dilated, and the ocular globes move. The patient will look at you and follow with his eyes. The senses are confused, but the patient often will obey when spoken to loudly.

In the second degree the mental powers are impaired although not suspended. The patient remains passive as if sleeping, or occasionally makes a semi-voluntary movement. Sometimes laughing, singing, talking, are indulged in. Snow believed that dreaming occurs at this time and then only. When more deeply narcotised the patient becomes restless, he attempts to remove the face-piece or inhaler, for he is conscious of being inconvenienced by the vapour but not of the necessity for remaining passive. Common sensation is much blunted, so that patients submit without expostulation to painful manipulation. This degree of narcosis is sufficient in parturition, and the after stage of prolonged operations. As a rule, struggles or expressions of pain which show themselves at this time are not remembered subsequently. The respiration and circulation are both quickened, the former being rendered more shallow and at times interfered with by contractions of the skeletal muscles and of the diaphragm. Spasm of these muscles may occur, accentuating this cause of respiratory disturbance. The pulse, accelerated at first, towards the close of this degree drops to or below the normal rhythm and is weakened in force. The ocular globes remain movable, the light reflex persists and the pupils are dilated. Salivation and a desire to expectorate are commonly present. This degree of narcosis is frequently profound enough for the performance of operations upon children, who even if they move slightly are unaware of what is being done to them. It is, however, never wise to operate until the third degree of narcosis has been attained.

In the third degree all voluntary movements are lost and complete anæsthesia is present. The conjunctival vessels become full, the muscles rigid, and struggles, even epi-

leptiform convulsions, may supervene. As the narcosis becomes deeper the muscles relax, and inarticulate jabbering and mouthing cease. Although really insensitive to pain, the patient may in the early part of this degree wrinkle his forehead, flinch, or even cry out. Later, reflex acts are abolished, the conjunctival and nasal receding late. The patella jerk persists for some time, while under deep anæsthesia the ankle joint phenomenon appears in some cases.

Rectal reflex influence upon the respiration will often be present throughout this degree of anæsthesia. The respiration and circulation settle down to the normal, or even grow distinctly weaker, and some pallor may be seen. The buccal muscles ceasing to act, the cheeks are blown out during expiration, the chin drops, through the weight of the tongue, and interference with breathing may result from falling back of the tongue towards the laryngeal aperture. The ocular globes now become fixed, and although the light reaction persists the conjunctival reflex is completely lost. The pupil contracts and remains smaller than normal. The lower lid no longer travels upwards to protect the globe as it does in the lighter degrees of narcosis when the upper lid is lifted. In rare cases the skin shows a slight rash like that seen in ether narcosis, but it rapidly disappears, leaving the skin cold and pale.

The fourth degree.—At this period the patient is profoundly unconscious and in extreme danger; the centres in the medulla oblongata are unduly narcotised and respiration and circulation enfeebled. Such deep narcosis is seldom needed, save for the reduction of old-standing dislocations, in deep dissections, and in the case of alcoholics; and necessitates the use of a strong vapour.

It is marked by corpse-like flaccidity of the muscles, pallid or bluish skin, deep stertorous breathing gradually

growing difficult, irregular, shallow, and unduly diaphragmatic, while the pulse is quick, compressible, and feeble, becoming almost imperceptible. The ocular globes are fixed, the pupils are widely dilated and no longer react to light. This degree corresponds to increasing paresis of the centres in the floor of the fourth ventricle.

The fifth degree is the interval which, following the fourth degree of narcosis, intervenes between the respiratory embarrassment and total cessation of breathing. Even after dyspnœa has been succeeded by cessation of respiration the heart may beat feebly for a brief time, the circulation growing more weak and the heart eventually stopping. In this degree the centres in the medulla oblongata are completely narcotised and no longer able to conduct or control the essential processes of life. Gradually failing respiration culminating in its complete cessation, followed by complete failure of the circulation with paralytic dilatation of the heart, wide dilatation of the pupils, extrusion of fæces and urine, mark this final degree of narcosis.

The phenomena described as occurring in the degrees of narcosis vary somewhat in different persons. In the alcoholic, for example, the excitement is very marked and prolonged. These persons may remain restless, their muscles being rigid and movements occurring even when they appear to be completely under the influence of the anæsthetic. Neurotic people also are prone to move and appear restless; their respiration and circulation may be, and commonly are, adversely affected by reflex influences even when the usual signs of anæsthesia are present.

It may be convenient to consider more in detail the phenomena which appear as the patient passes through these degrees of narcosis. The divisions mentioned are

of course artificial, and merge insensibly one into another; but the physiological effects which the inhalation of chloroform produces are continuous and vary directly as the strength of chloroform vapour which reaches the lungs.

The effects on blood circulation.—The arterial pressure at first rises, the rise is commonly slight, and is due, if we accept the experimental work of Gaskell and Shore, to an initial stimulation of the vaso-motor centres. This is followed at once by a gradual fall of blood pressure. Schâfer and Scharlieb, who have re-investigated the action of chloroform upon the heart and blood vessels, regard chloroform as a vaso-constrictor. The later fall of blood pressure, they believe, is due to progressive weakening of the heart muscle. The pulse of the patient is quickened as he commences to inhale and slightly increased in force, but it rapidly grows less full and may become markedly feeble. The fall in blood pressure is admitted by all competent authorities, but the interpretation of its cause is matter of dispute. McWilliam has shown that as soon as chloroform enters the blood, and its absorption by the pulmonary vessels is extremely rapid, it is conveyed through the coronary vessels to the heart muscle. This result is evidenced by weakening of the action of that organ as it gradually loses its contractility and finally undergoes paralytic dilatation. The recent research of Sherrington and Sowton has made it clear that even very small quantities of chloroform act at once upon the heart muscle, but provided that the amount of the anæsthetic does not exceed a certain limit the muscle accommodates itself to the chloroform, and its force of beat, although lessened, is not unduly diminished. When, however, the percentage dose is increased, and the limit is a narrow one, the heart muscle becomes paralysed and is irrecoverable. The weakening

of the cardiac contractions undoubtedly leads to a fall in the blood pressure. As a result the nervous centres, like the heart muscle itself, become deprived of their proper blood supply and cease to maintain the regulating mechanism of the blood circulation. Leonard Hill in the course of his valuable work on this subject has shown that when the central nervous system is deprived of its due supply of blood it is more readily affected by chloroform, as indeed by all narcotic poisons. A percentage which will not prejudice the nervous centres of a person whose blood pressure is normal, will prove fatal when the blood pressure has undergone declension. And not only does this occur, but as a result the tonus of the whole arterial system becomes damaged or destroyed, and the blood drains from the arteries into the veins. The force of gravity which in the physiological state assists the circulation now causes the blood to accumulate in the large veins of the abdomen (the abdominal pool of Hill) and the circulation comes to a standstill. The truth of these statements has been called in question by the meritorious work of the Second Hyderabad Commission due to the splendid zeal and enthusiasm of Lieut.-Col. Lawrie, but it must now be admitted that all physiologists are agreed upon the matter and claim that the tracings published by the Hyderabad Commission themselves demonstrate the gradual weakening of the heart under the influence of chloroform. The great value of the work done by the Hyderabad Commission undoubtedly is the abundant proof the experiments afford of the danger of obstructed respiration. Although primary heart failure probably does occur in any degree of chloroform narcosis—but this the Commission denies—yet one of the commonest causes of death under chloroform is interference with respiration through overdosage and secondary failure of

circulation. Leonard Hill, however, has indicated that although this reasoning is apparently correct yet, as a matter of fact, the sequence of events is a vicious circle. The patient inhales an overdose of chloroform, an overdose usually due to too high a concentration of the vapour, the blood pressure falls in spite of a possible initial rise due to asphyxia, and the respiratory centre ceases to enjoy its proper supply of blood. Then comes respiratory embarrassment and ultimately fatal interference with circulation.

The mechanism by which this "primary heart failure" occurs has been described by Leonard Hill and may be given in his words:—"Concentrated vapour of chloroform is presented to the respiratory orifice, the nerve endings of the sensory fibres of the vagus in the respiratory tract are powerfully excited. The animal struggles, the glottis is closed, and by the violent contraction of muscles the intra-thoracic pressure is raised. . . . The effect of raising the intra-thoracic pressure is to diminish the output from the right heart, to congest the venous system and lower the arterial tension; the lungs are also compressed and to a great extent emptied of blood. Blood supply to the coronary arteries is diminished; this is due to the fall of arterial tension. The oxygen in the blood is decreased owing to the prolonged holding of the breath. By these means the nutrition of the heart is impaired. Finally, owing to the excitation of the respiratory centres caused by the asphyxial blood, the animal is forced to take two or three deep inspirations. The lungs are immediately surcharged with chloroform vapour, and the blood reaches the coronary arteries carrying a dose of chloroform sufficient to throw the heart into paralytic dilatation." Syncope occurring thus early in the inhalation appears to explain a large number of fatalities under chloroform

which have been recorded. It is usually reported that "the patient struggled, became suddenly pale, the heart stopping, and after giving one or two gasps, died without showing any response to artificial respiration." As has been justly pointed out by Lawrie, such deaths ought never to occur if the administrator is watching the respiration and as soon as any holding of the breath occurs withdraws the chloroform until the breathing becomes natural. Sherrington has shown that provided the concentration has not been too great, recovery will take place, since blood pressure has not fallen too much and the heart muscle has not undergone the "paralytic dilatation" of McWilliam. The initial fault is, of course, using too concentrated a vapour, and what often happens is that one deep inspiration of the concentrated vapour is taken, and this in many subjects suffering from a dilated or feeble heart may prove fatal. It cannot be too strongly insisted upon that it is not so much the quantity of chloroform taken as the degree of concentration of the vapour inhaled, which leads to the fatal result.

A further consideration with regard to primary syncope under chloroform is the danger of syncope due to fear.

In the days when anæsthetics were not commonly used, death before the operation was not unusual and was attributed to fear. A similar experience is at the present time to be met with during the use of local analgesia. The patients in many cases although suffering no pain, vomit and faint from the emotion of seeing and hearing the steps of the operations upon their bodies. Now, with respect to fear-syncope under chloroform, it might be supposed that the chloroform inhalation was merely a coincidence with the syncope, if it were not for the fact

that such cases of fear-syncope are extremely rare, if they ever occur, under ether. Probably, the depressant action of the chloroform on the one hand, leading to weakening of the heart beat with fall of blood pressure, and the stimulating effect of ether on the other with its increased cardiac contraction, make all the difference in the ultimate issue of the case.

In the later degrees of chloroform narcosis syncope may arise from another cause. With the diminution of arterial tension and the progressive weakening of the respiration, due to the anæmia of the medulla oblongata arising from the falling blood pressure, the chloroform still enters the lungs and is conveyed to the circulation. There is no undue concentration of vapour in the ordinary sense, although the continuous inhalation of the vapour of the particular concentration leads to overloading of the blood with chloroform, and to slow but progressive fall in arterial tension. As the respiratory centre becomes anæmic it is more readily paralysed by even a small quantity of the narcotic, and finally is unable to carry on its functions. When the respiration progressively fails, so does the circulation grow feebler and finally ceases. But this gradual syncope is, according to Hill, not the result either of respiratory failure or asphyxia. After respiratory failure, if the heart is still able to contract, as a rule, the patient can be restored when artificial respiration is carried out. In the sudden failure of circulation arising from paralytic dilatation of the heart no resuscitative measures are of much avail. It may again be pointed out that even here *watching the respiration*, if thoroughly done, would safeguard the patient, especially if, as should always be done, the degree of pallor of the lips be observed. Whether accumulation of chloroform can take place in the blood even when a comparatively dilute

vapour is being inhaled, is at present open to question, but it seems at least probable that accumulation in a certain sense does occur. Vernon Harcourt's investigations appear to prove that, during prolonged inhalation of chloroform, the expired air at first contains more than half the amount of chloroform inspired; later, a larger quantity is given off, and when the anæsthetic is given in lower percentage the expired air may contain more than that inspired. It is certain that the force of expiration gradually fails during prolonged chloroform inhalation, and so if the expired air does not eliminate sufficient chloroform vapour a gradually deepening degree of narcosis must occur. This takes place so slowly that only the greatest care enables the administrator during a protracted operation to recognise the over-narcotism. In the emphysematous, expiration being ineffectually performed, even from the first, there is an especial risk of this. And again during protracted operations, when bleeding is severe, the lessened quantity of the blood in the body will make a much smaller dose of chloroform sufficient to paralyse the medullary centres. Struggling plays an important part in bringing about syncope under chloroform in the period corresponding to the first two degrees of narcosis. It increases the liability to an increased intake of chloroform and by causing fixation of the thorax increases the intra-thoracic pressure, and so puts a severe strain upon the heart as well as interfering generally with the mechanism of circulation. Such interference must tell with especial force upon the cerebral circulation. The effect of posture also is one of primary importance upon the determination of syncope. As Hill has shown, when the vaso-motor system is rendered paralytic by chloroform the "stopcock action" of the capillary system ceases to work, and, as a result, the arteries at once empty

themselves of blood. The force of gravity, when the vaso-motor system is intact, assists circulation, otherwise it favours the accumulation of the blood in the veins. Under these circumstances, when the person is placed in the feet down posture the brain and medulla at once empty of blood and the medullary centres being anæmic can no longer energise. Several deaths have occurred of persons who, during a recovery from profound narcosis, either have been lifted or have risen into the sitting position and have at once fainted and died.

We know further that the vagus nerve mechanism plays an important part in the causation of death under chloroform. Embley, who has investigated the question of fatalities in the early degrees of narcosis, and Schäfer with Scharlieb, who have studied the effects of chloroform upon the arteries and heart, come to conclusions which may be briefly summarised. The vagus nerve mechanism when influenced by chloroform rapidly obtains an enhanced power of inhibition over the heart. As we have shown, the anæsthetic by causing acute dilatation of the heart directly weakens it and brings about a fall of blood pressure. It is this declension of arterial tension which renders the heart less able to escape from the vagus control, and inhibition partial or complete ensues. With cessation of the heart's action the blood pressure falls to zero and respiration stops. Embley has proved that this dangerous inhibition is liable to occur in the case of the lower animals whenever the strength of the chloroform vapour in the air inspired rises above 2%. Whether, as has been suggested, the vagal action is exercised reflexly through nerve endings in the nasal, laryngeal, or pulmonary areas is open to some question, although it seems probable. It is certain, however, that the theory of such reflex mechanism

is insufficient to cover the whole ground. For when all reflexes are experimentally eliminated, vagal inhibition still occurs and is then due to the hyperactivity of the vagus nerve mechanism and is induced by the chloroform in the blood stream. This is a danger of the induction period, and when that is safely surmounted the vagus action ceases to make itself felt, its excitability being depressed. It is liable, however, to be raised again by increasing the strength of the vapour of chloroform, or by asphyxia. The degree of readiness with which this can be done depends upon the duration of the administration and the endurance of the vagi.

Respiratory system.—As soon as the initial excitement has passed off the force of the respiratory movements is lessened. Expiration is more affected than inspiration, and the thoracic excursion is obviously lessened as inhalation proceeds. What are the alterations in the gaseous exchanges during light and deep narcosis we have yet to learn, but that they become progressively less there is every reason to believe.

To understand the mechanism of chloroform narcosis the following facts should be considered:—

Chloroform vapour enters the blood until an equilibrium is established between the tensions of chloroform in the alveolar air of the lungs and that in the blood itself. So long as the tension in the air is maintained equal to or above that in the blood, no chloroform can leave the latter through the agency of the pulmonary mucous membrane. Snow demonstrated this theoretical assertion by actual experiment, substantiating the truth of the *à priori* statement, and so he arrived at the following law:—"As the proportion of vapour in the air breathed is to the proportion that the air, or the space occupied by it, would contain if saturated at

the temperature of the blood, so is the proportion of vapour absorbed into the blood to the proportion the blood would dissolve."

The amount of vapour which can be taken up (held in suspension) by the air of the atmosphere, varies with the elastic tension of the chloroform vapour at different temperatures. Thus at 40° F. a small quantity of chloroform would evaporate into air; at 130° F. so much would volatilise as to give rise to an almost pure chloroform vapour. Snow's results, given below, were obtained by less exact methods than are now possible. His facts and inferences have been substantiated to a great extent by others, and by recent researches.

One grain of chloroform in one hundred cubic inches of air produces the second degree of narcosis, but never carries chloroformisation further. This corresponds to a proportion of one part, by measure, of chloroform in 16,285 parts blood, or 0·0000614 the proportion by weight. Two grains in each hundred cubic inches of air, or $\frac{1}{28}$ saturation (unity being saturation), produces the fourth degree of narcosis, or 0·0001228 the proportion by weight.

Two grains or more in the hundred causes interference with respiration, three grains in the hundred seems about the ratio which renders respiration impossible. Three grains represent 2·3 cubic inches vapour, and as air at 100° F. can take up 43·3 per cent. of its volume, the blood must contain from $\frac{1}{18}$ to $\frac{1}{19}$ of the proportion it is capable of absorbing when the respiratory centres are poisoned.

The appended table (Snow) * shows at a glance the quantity of vapour, in 100 cubic inches of the saturated mixture of vapour and air, at different temperatures.

* "Anæsthetics," p. 33.

Degrees, F.	Air, per cent.	Vapour, per cent.
40	94	6
45	93	7
50	92	8
55	90	10
60	88	12
65	85	15
70	81	19
75	78	22
80	74	26
85	70	30
90	65	35

Snow found further, that calculating the weight of the blood as thirty pounds, twelve minims of chloroform in the circulation produces narcosis of the second degree; eighteen minims would induce the third degree (surgical anæsthesia); twenty-four deep narcosis (fourth degree); and thirty-six paralysis of the medullary centres. In practice more is needed because a certain proportion evaporates from the tracheal and bronchial surfaces and is carried out in expiration. If twelve minims be evaporated into a bladder and inhaled to and fro, no more air being allowed than can be blown through the lungs, narcosis of the second degree actually results. Now, taking thirty-six minims as a lethal dose, the following considerations, upon which Snow strongly insisted, explain how easily this quantity may enter the circulation if the administrator be not perpetually upon his guard against overdosage; 18 minims represent the amount absorbed to produce surgical narcosis, this amount might be absorbed by the use of 36 minims, the remaining 18 minims being exhaled as above mentioned. These 36 minims represent 37·5 cubic inches of vapour, which

at 60° F. would require 257 cubic inches of air. The 300 cubic inches thus formed would be inspired in twelve respiratory acts (25 cubic inches being the amount of tidal air). Now, if a vapour of this strength were continuously inhaled, the residual and complemental air would become saturated, and as about 250 cubic inches represents the air in the lungs, this amount would at 60° F. contain the vapour of 30 minims. Assuming only half this quantity to be absorbed, that is 15 minims, we should then have 18 + 15 or 33 minims in the blood, an amount almost if not quite enough to paralyse the respiratory centre. These points being held in remembrance will explain many cases of chloroform death, ascribed to "idiosyncrasy" or the "fatty heart" which stands inexpert chloroformists in such good stead.

The lesson which these facts appear to the writer to emphasise is, that chloroform to be used with safety must be employed in low percentages. If we translate Snow's figures into percentages we find that he and Paul Bert agree in fixing a two per cent. as the strength of vapour which produces the third or anæsthetic degree of narcosis. Double this and we reach the quantity which kills. The problem is no doubt a complex one when chloroform is administered to a patient, but there is little doubt, if any, that there exists a very narrow margin of safety when we transcend the two per cent., and that unless we are prepared to run a considerable risk we must keep within this percentage.

These considerations, which cannot be studied too carefully, point out the importance both of avoiding an overdose of chloroform, and of maintaining a due elimination of the drug. The Hyderabad Commissions again and again urged the grave dangers which follow when asphyxia (by which is meant impediment to thorough air

exchange in the lungs) is permitted to complicate chloroform narcosis. Such asphyxia of course means impaired elimination, itself tantamount to accumulation of chloroform in the blood. Broadly speaking, it is true to say that a dose of chloroform which is safe, provided due air exchange is ensured, rapidly grows dangerous when its elimination is interfered with. It is thus evidently a fallacy to urge that if only a small quantity of chloroform is given the patient is free from danger. The peril lies not in the quantity of chloroform inspired when breathing remains unimpeded, but in the strength of the vapour entering the lungs. In this sense breath holding and lowered blood pressure may, it has been alleged, be accepted as safeguards, since on the one hand the intake of the vapour is stopped, and on the other the deportation of the chloroformed blood is lessened. But, inasmuch as the holding of the breath is always followed by one or more vigorous inspirations, which convey large, often fatally large, quantities of chloroform to the medulla, while a lowered blood pressure and feebly acting heart depress the vitality of the tissues and render the medullary centres more prone to be poisoned and also increase the danger from vagal inhibition, these conditions are really fraught with grave danger to the chloroformed patient.*

The Administration of Chloroform.

Many methods have been proposed. They may be classed as (1) those requiring the use of some apparatus or inhaler and (2) those in which chloroform is given by dropping it upon a towel, handkerchief, lint, etc. In this second class

* A careful research upon the chemical changes produced in the organs and tissues by the inhalation of chloroform will be found in "Physiologie Travaux du Laboratoire du Ch. Richet," p. 413, 1898, by Dr. Vidal.

the various plans adopted are commonly grouped under the heading of "The Open Method," although as will appear from the sequel, while some of the modes of procedure are truly "open," some are not more "open" than when the use of an inhaler is adopted.

I. **Inhalers.**—Among the first designed to supply a definite percentage vapour of chloroform were those of Snow,* Clover,† Sansom,‡ Squire, and Junker,§ all of which, except the last, have passed into desuetude. Junker's inhaler has, at the present time, undergone many and important modifications. There is no doubt that the principle which these instruments were constructed to carry out, viz., the regulation in definite proportions of the quantity of chloroform inhaled, is the correct one. No method, indeed, which does not enable the administrator to adopt this principle is a safe or reliable one. The inhalers which supply more or less exactly a definite percentage of chloroform vapour to air are those devised by Dr. Raphael Dubois, Mr. Vernon Harcourt, and Dr. Levy.‖

The Dubois Apparatus.¶

This apparatus delivers a definite percentage vapour to the patient, who is thus always breathing the same strength of chloroform vapour diffused in air. The strength of the vapour inhaled is independent of the force and frequency of the respirations. The required percentage is easily adjusted to the requirements of the case. As the apparatus is

* "On Anæsthetics," p. 81.

† *Medical Times and Gazette*, Aug. 9, 1862.

‡ "On Chloroform," p. 127.

§ *Medical Times and Gazette*, 1867, vol. ii., p. 590.

‖ *Lancet*, May 27, 1905.

¶ For a full description of the apparatus see *Anesthésie Physiologue*. By Dr. Raphael Dubois, Paris, 1894, p. 106, *et seq.*

and 18° C.* To compensate for varying rates of respiration the inlet and outlet of the bottle are placed near together and at some distance from the surface of the liquid, while to compensate for the lowering of the liquid surface by evaporation the vessel widens as the surface of the chloroform descends. The nearness of the two necks one to another, and the distance between them and the surface of the chloroform, diminish the variation in the proportion

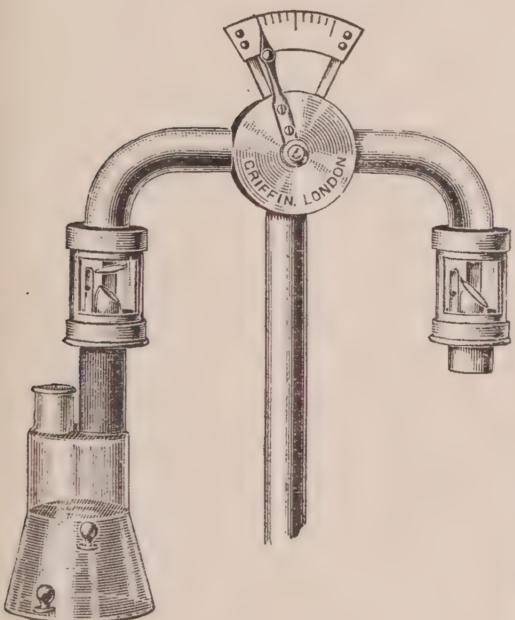


FIG. 36.
Pointer adjusted to give 2 per cent.

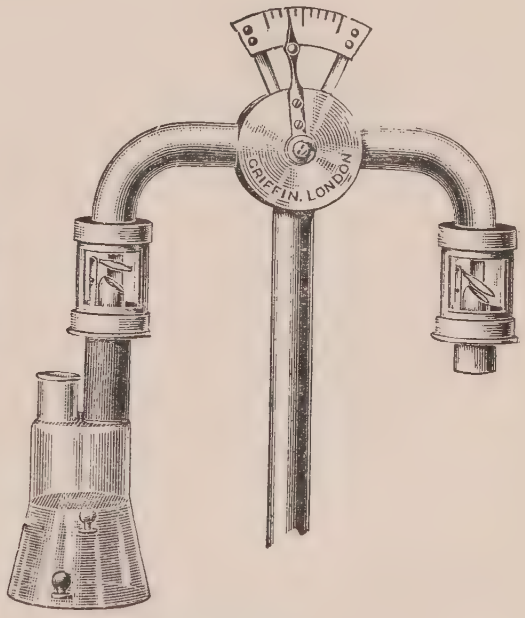


FIG. 37.
Pointer adjusted to give 1·4 per cent.

of inhaled air to chloroform vapour which is caused by abnormally shallow or deep breathing. When the flow of air is gentle, much of it passes in at one neck and out at the other without reaching the surface of the chloroform or displacing wholly the mixture of air and chloroform which occupies the upper half of the bottle. On the other

* The first apparatus was graduated for the temperature 13° to 15° C., but for ordinary use it is better to have the bulbs made to indicate the temperature mentioned above, otherwise the percentage is liable to fall too low.

hand, the strong current caused by deep breathing drives out all the vapour which has been formed and promotes further evaporation by stirring the surface of the liquid. With bottles of the present dimensions this correction is only partial. If the rate of breathing is voluntarily reduced to 3 litres a minute instead of the normal 4 or 5 litres, or raised to 7 or 8 litres a minute, the proportion of chloroform may be raised to about 2·5, or lowered to about 1·5 per cent. It would not be difficult by lengthening the cylindrical part of the bottle to correct more completely for variations in the rate of breathing. But it is believed to be advantageous that the proportion of chloroform should vary thus, in order that there should be less variation in the total quantity of chloroform administered. Two ratios have to be considered in judging of the probable effect upon a patient, that of chloroform vapour to air, and that of the mass of chloroform inhaled to the mass of the body through which it is distributed.

The stopcock is so made that when the pointer is at the end of the arc nearest the bottle of chloroform the maximum quantity is being administered—namely, 2 per cent. When the pointer is at the opposite end only air will be inhaled; and when it is midway dilution of the 2 per cent. mixture with an equal volume of air will make the proportion 1 per cent. The shorter lines on either side indicate intermediate quantities—namely, 0·8, 0·6, 0·4, 0·2 per cent.; and towards the chloroform bottle, 1·2, 1·4, 1·6, 1·8 per cent.

The valves on the two branches prevent the entrance into the apparatus of expired air, and also serve to show whether the stopcock is working rightly. Only one valve opens when the pointer is at either end of the scale, both equally when the pointer is midway, and for all other positions one valve opens more and the other less, in the

degree indicated by the position of the pointer on the scale. The movement of these valves shows also how full and regular the breathing is, and the slight click which they make conveys this information to the ears when the eyes are otherwise occupied.

It is generally found that beginning with the pointer at 0·2 per cent., and moving it on towards the chloroform bottle at the rate of one division about every half-minute up to 1·6 per cent. or 1·8 per cent., produces narcosis as quickly as is desirable.

For the maintenance of narcosis it is believed that 1 per cent. or even less will be found sufficient. The stopcock can be moved by a touch of the finger so as to increase or diminish the dose.

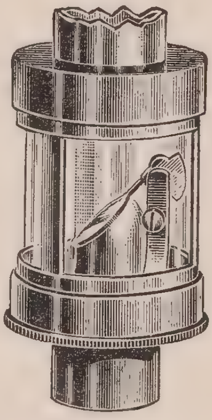


Fig. 38.
Valve chamber.

If by fall of temperature, or agitation of the bottle, the yield of chloroform is diminished, or increased, this may be allowed for at once by a movement of the stopcock.

The face-piece, which is provided with an expiratory valve, and can be fixed in any position, is either attached directly to the inhaler, which in this case is held in the hand, and should be kept as nearly vertical and as steady as possible; or can be connected by about 20 inches of half-inch rubber tubing, the inhaler in this case being supported on a stand, or attached to a sling passing round the neck of the administrator or to the back of the bed.

The mask is made of solid toughened rubber, fitted with a rubber air-cushion. It can be washed, or boiled, and as it becomes plastic in hot water the shape can easily be modified, if required, so as better to fit the patient's face.

Certain cases may occur in which a stronger dose is

required than that afforded by the apparatus as above described. For increasing the strength of the vapour inhaled a small tube is provided which fits into the open neck of the bottle, raising the possible maximum dose to 2·5 or 3 per cent. To obtain a 2·5 per cent. mixture the larger end of the tube, marked 2·5, must be inserted in the bottle, and for 3 per cent. the smaller end, while the pointer is kept at the end of the scale nearest the chloroform. At intermediate positions of the pointer the dose will be increased in the same proportion as the maximum.

FIG. 39.
Increase of percentage tube.

No chloroform evaporates excepting that which is inhaled by the patient; and only that which is exhaled passes into the air of the room.

Use of the inhaler.—The apparatus must be carefully examined to see the parts are adjusted, and the administrator should inhale, or incline the instrument sideways, to see that the valves are working properly. About 2 oz. of chloroform should be poured into the conical bottle and the beads introduced. The face mask should then be carefully applied. This is best done when the head is turned to one side. Breathing taking place freely and the air inlet valve and expiry valve working properly, the inhaler should be grasped at the horizontal cross-piece with the right hand, while the lower jaw is pressed forward by the left hand placed behind its angle. Firm pressure is necessary, as absolute co-adaptation of the mask to the patient's face is essential. If the pressure used is equal over the whole area of the face the patient will not complain. It is a common fault to allow air to enter by the sides of the bridge of the nose. Absolute fitting of the face-piece having been secured, the strength of the vapour may be gradually increased by turning the pointer.

This is done slowly, but, unless the patient is restless and struggles, not very slowly. Struggling is an indication for lessening the strength of the vapour, but not for the removal of the face-piece unless duskiness supervenes. When anæsthesia is attained, the usual signs being relied upon, its maintenance can be effected in most cases with 1·5, 1, or even ·5 per cent., according to the physique of the patient and the requirements of the operation. After prolonged administration slight duskiness may appear, and in this case the apparatus may be lifted for a few breaths and then replaced.

A few points remain to be noted. I have found it convenient for the horizontal portion of the inhaler, connecting the vertical from the face-piece to the vertical from the inhaler, to be made double the length shown in the drawing. And, further, to place the expiry valve at the distal end of the vertical from the mask, instead of on the face-piece. By this means it is possible to keep the inhaler out of the field of operation and to maintain a firmer grasp of the mask, without interfering with the expiry valve. It has been pointed out that shaking of the chloroform bottle and variations in the rate and force of breathing alter to an appreciable extent the actual amount of chloroform inhaled. The shaking of the bottle need never occur, especially if the inhaler is removed from the patient's face while he is lifted on to the operating table, or when his posture has to be changed during the operation. The variations in the rhythm of respiration occur during the period of induction, and in practice give rise to no difficulty. In using this, as in the case of any inhaler, the anæsthetist must of course be guided by the usual signs of chloroform narcosis, and when it is too profound the indicator should be turned to 1 per cent. or whatever strength of vapour seems desirable. It cannot be too strongly insisted

upon that the Vernon Harcourt Regulator is only a means to an end. It supplies a fairly accurate method of regulating the percentage of chloroform presented to the patient, but it does not, nor can any inhaler, abrogate the necessity for a competent knowledge of the action of chloroform on the human subject and experience in administering that anæsthetic. *The apparatus need not, and must not, detach the chloroformist's attention from his patient's condition;* it merely enables him to increase or decrease the dose of chloroform as may be necessary. Observation of the patient's condition will indicate when the necessity arises. In using the inhaler, care should be taken that there is accurate apposition of the mask to the face, otherwise the vapour supplied will be below the necessary 2 per cent. and failure may result. A piece of wet lint will in some cases assist in securing air exclusion. This is laid over the chin and folded up in the hand, holding the mask in such a way as to prevent air being sucked in around the air-pad. The air-pad should always be well inflated before use. It is also necessary to see that the valves are acting and the expiry valve is not covered up. The inspiry valves should be in a horizontal plane, and the whole apparatus placed out of the reach of the operator or his assistants.

It is sometimes convenient to suspend the body of the apparatus so that it is placed in front of the anæsthetist and fastened to a strap or bandage looped round his neck. In this case the centre portion or airway is to be connected with the arm attached to the face-piece by means of a long piece of tubing. The bore of the tubing must equal that of the lumen of the metal tubes. Steadiness may be obtained by fixing the body of the apparatus in a stand which is placed on a table or fixed to the operating table, and connecting it as above by means of tubing with the face-piece.

Speaking from an experience of three years and some thousands of cases, many of the gravest character, I may say I have found the inhaler fulfils all the purposes for which it was constructed. It supplies a 2 per cent. vapour or a little more, and this, in practically all cases, produces profound narcosis. It is easy to manage, and when once learned will prove reliable and satisfactory. There have been no dangerous symptoms due to the anæsthetic in the cases in which I have used the inhaler, and no failures. It has been increasingly rare for me to have to employ any percentage higher than that afforded by the inhaler; and even in the few instances in which I have replaced the inhaler by another, the necessity has usually arisen from the difficulty experienced in making the face-piece fit accurately.

Dr. Levy's Regulating Inhaler.*

This, like the Vernon Harcourt regulator, is devised upon the "draw over" principle, but differs in several particulars, which may be summarised as follows:

(i) The range of the available strength of vapour extends up to 4 per cent.

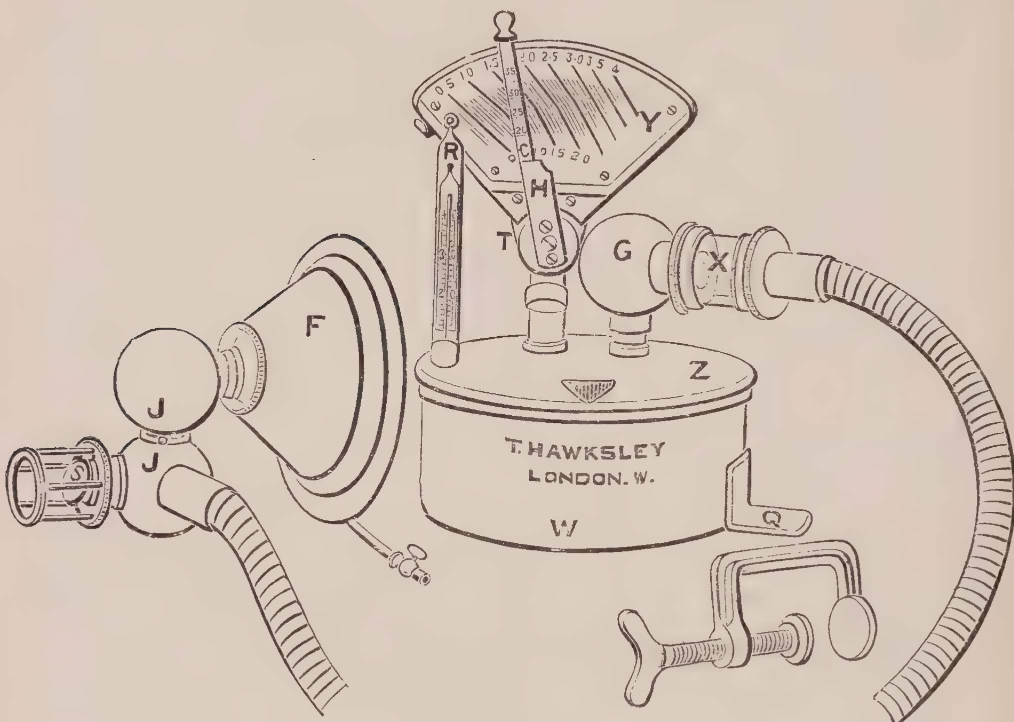
(ii) The principle of the water bath is applied to the regulation of the temperature of the chloroform, which therefore requires no active attention.

(iii) It is designed for use only when fixed to a table or other support, in order to obviate the possibility of any error arising from accidental agitation of the chloroform.

(iv) The percentages of vapour are accurately controlled even under the diverse conditions of draught consequent upon different types of breathing. A difficulty occurs

* *Lancet*, May 27, 1905. Cf. *Medico-Chir. Soc. Trans.*, vol. 88, p. 673.

under ordinary conditions of aspiration over a surface of chloroform, in that a slow current of air, such as would result from a faint inspiration, takes up a larger proportion of vapour than does that resulting from breathing of a more vigorous type. An adjustment is brought about in this instrument by applying a two-fold principle. Firstly,



Dr. Levy's Chloroform Inhaler.

FIG. 40. The complete apparatus seen from the front. F, Face-piece. G, Globe in which air and chloroform currents mix. H, Index-hand. J, Globes forming a double junction between the face-piece and the tubing. Q, Foot, which is clamped to the edge of a table. R, Thermometer immersed in the water bath. S, Expiratory valve. T, Tap for regulating chloroform supply. W, Water bath. X, Glass valve chamber (containing inspiratory valve). Y, Percentage scale. Z, Cover of water bath.

only a fraction of the inspired atmosphere passes through the chloroform container; this vapour-laden portion is charged to a high percentage, and it naturally moves at a slower rate than would the total inspiration. Such

fractions of inspirations exhibit relatively less change of composition for varied inspirations than would be the case if the whole of the inspired air passed over the chloroform. The complement of pure air is drawn through a large aperture which is permanently open, and in this way the percentages of vapour in the mixture are approximated. Secondly, the "chloroform current" traverses a series of tubes and passages, and in consequence undergoes a certain retardation which tends to be more pronounced during weak suction; the influx of pure air through a simple aperture not being retarded to the same extent, it follows that the dilution becomes greater during faint inspirations. This supplementary process supplies the finishing touch, which renders the percentages practically identical for all forces of suction commonly found under chloroform narcosis.

The body of the inhaler consists largely of a vessel which is filled with water at a temperature of 104° F., and the chloroform container forms a part of the cover of this vessel; the supply of air to the chloroform is controlled by a tap which is manipulated by an index hand, and the position of this indicates on a scale plate the percentage being delivered, a simple form of correction being applied for any temperature of water between 104°—52° F. A length of wide-bore aluminium tubing and a double junction serve to connect the body with the face-piece. Two hinged aluminium valves, inspiratory and expiratory, complete the apparatus, which has generally been constructed with a view of presenting the least possible resistance to the passage of the inspired air.

Mr. Hobday, F.R.C.V.S., has introduced a very useful chloroform inhaler for veterinary purposes. It is constructed upon the "draw over" principle, the patient aspirating chloroform vapour with the inspired air. It

does not, however, supply a definite percentage vapour. In spite of this it is much safer than the usual means adopted for anæsthetising the lower animals.

II. The inhalers constructed upon the principle of propelling air through chloroform, and so presenting a vapour to the patient which he aspires, are best represented by Dubois' anæsthetic machine and Junker's inhaler. The former supplies definite percentages, and is more adapted for hospital practice.* Junker's inhaler is portable, but is only approximately accurate as a means of giving definite percentages, and its use is not free from danger.

Junker's Chloroform Inhaler.

This **inhaler** has been modified by many persons. It was designed for use with "methylene," but now, as that agent is seldom employed, the apparatus is used for the exhibition of chloroform.

It consists of a glass bottle fitted with a metal mount on which is screwed a metal cap, and to this are attached two tubes, one for ingress of air, one for egress of chloroform vapour and air; a Richardson's hand ball-bellows and a vulcanite face-piece with tubes which connect the bottle with the bellows and face-piece. Half an ounce of chloroform is placed in the bottle, and the top screwed on. To the ingress hole is attached a long metal tube extending from the metal cap to below the level of the chloroform, so that when the ball-bellows is compressed, air passes down this tube and ascends through the chloroform taking up vapour. Finally the vapour escapes by the egress tube into the vulcanite face-piece from which the patient inhales.

* See p. 202.

In my original modification of this apparatus, an ounce of chloroform is poured into a bottle* through a funnel-shaped opening fixed in a screw top. A foot bellows can be fixed by straps, one of which slips over the toes, while the other receives the heel in the long loop. When the foot presses lightly, the air in the bellows is forced through the tube into the bottle, thence through another tube to a face-piece. The net-enclosed ball is for equalising the stream of air and the avoidance of splashing. It is important not to put more than an ounce in the bottle at once, unless a large bottle is employed, and not to pump in air spasmodically or too forcibly, otherwise chloroform may be driven through the system of tubes into the face-piece. Even if this should not happen, a strong blast of chloroform-impregnated air is very unpleasant and deleterious if allowed to impinge upon the face. The longer tube in the bottle along which the entering air comes (afferent tube) should have its lower extremity tipped with some non-conductor of heat, such as wood or bone, to prevent freezing and blocking of the tube; and the exit tube (efferent tube) should be so constructed that in no position of the apparatus can liquid chloroform enter it. When the bottle

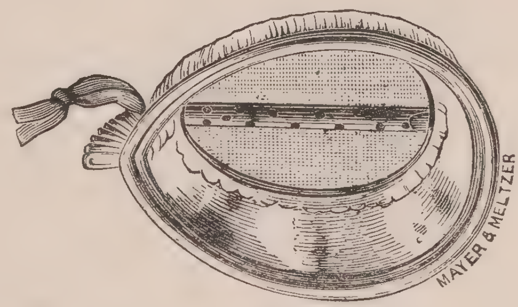


FIG. 41.
Glass face-piece (Dudley Buxton).

* The bottle I use is somewhat larger than the original pattern, as this gives the administrator a greater control over the chloroform. He can employ as dilute a vapour as possible, but can give a stronger one should occasion demand it. In the shorter bottles, if the upper surface of the chloroform is within a certain distance of the entry of the egress tube, liquid chloroform is forced up this tube. When this has once been done by vigorous compressions of the hand-bellows, syphon action is established and the contents of the bottle are pumped over, with dangerous results.

has become nearly empty, the mill-headed stopper which closes the funnel is removed and more chloroform added; thus the apparatus need never be unhooked from the administrator's coat, and the top never unscrewed until the administration is over, when the bottle should be emptied and cleaned.

In fig. 42 is shown the apparatus I have now employed

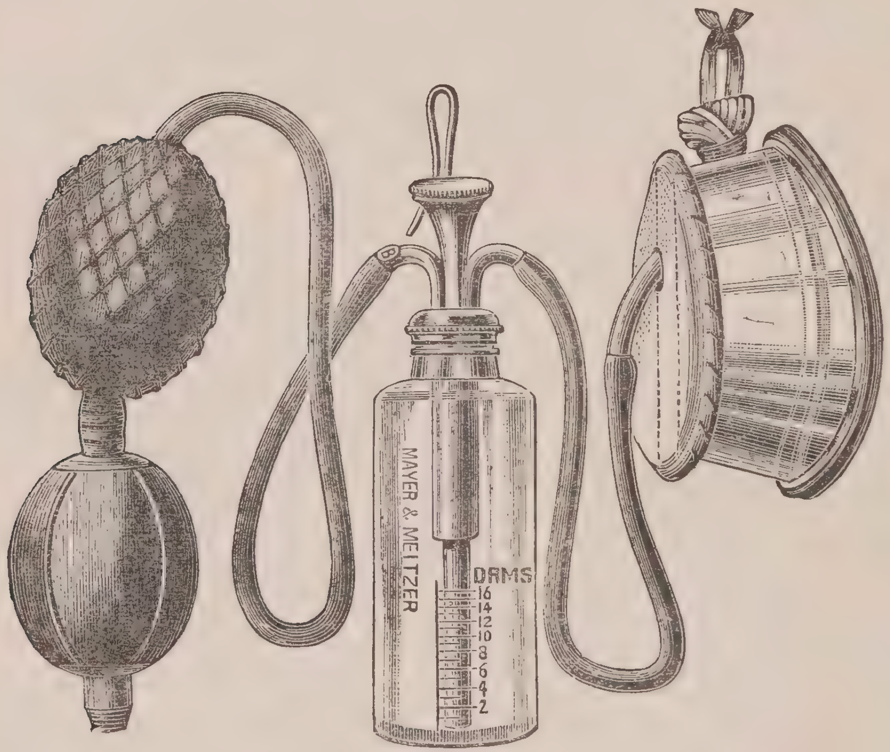


FIG. 42. Dudley Buxton's improved chloroform inhaler.

for some years, and which I have found to answer better than any of the older patterns. It consists of a somewhat larger Junker's bottle than usually supplied. The Skinner's mask is replaced by a glass face-piece (fig. 41), to which is fixed a metal rim carrying the air supply tube, and this delivers into a perforated tube running from back to front of the metal frame. There is a hinged rim which can be

raised to allow a piece of lint or domett being placed over the opening on the upper aspect of the mask. When this rim is shut down it locks itself and keeps the lint in position. This apparatus can be rendered sterile by boiling. The danger which existed in the older forms of the apparatus of liquid chloroform entering the efferent tube and so passing into the face-piece, can be avoided by bringing down the efferent tube as an ensheathing tube over the afferent tube. This will prevent chloroform entering the tubes, even if the bottle is inverted or laid upon its side. There must be at least an inch interval between the surface of the chloroform and the opening of the efferent tube, to avoid the possibility of fluid being forced or aspirated along the efferent tube. The bottle shown in the figure, although graduated for two ounces should never contain more than one ounce, otherwise the

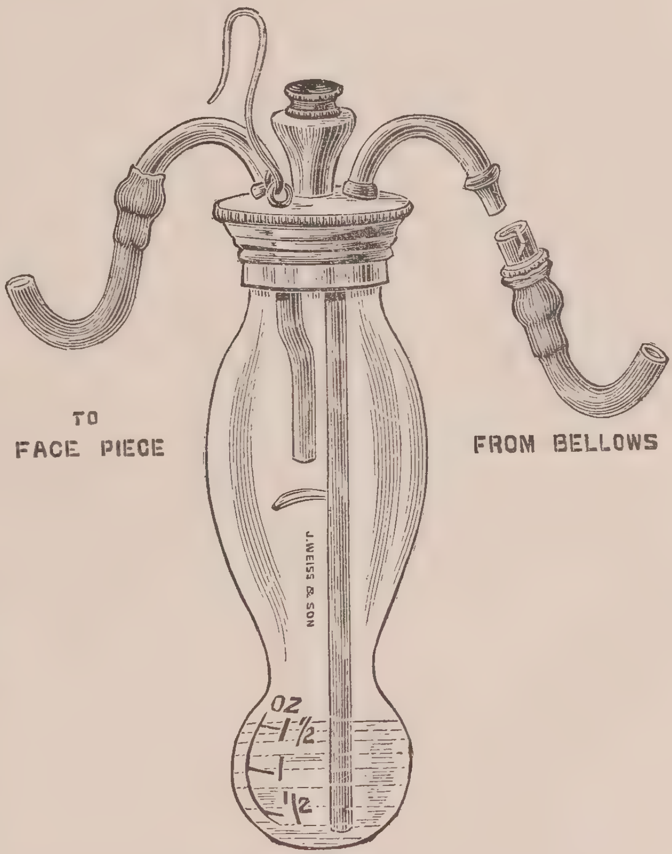


FIG. 43. Chloroform bottle for Junker's inhaler (Carter Braine).*

* I am indebted to Mr. Carter Braine for the woodcut.

requisite interval between the chloroform and the ensheathing tube is not maintained.

The bottle figured above is one devised by Mr. Carter Braine to obviate the danger of liquid chloroform entering the efferent tube (fig. 43).

There is also a danger if the india-rubber tubing from the bellows, and that to the face-piece, the afferent and efferent tubes respectively, are attached to the wrong tubes on the bottle, lest chloroform be pumped out of the bottle along the efferent tube to the face-piece. This is more perilous when a mouth or nasal tube is in use. Dr Hewitt has suggested to remedy this danger by the use of ensheathing tubes and an arrangement upon the bottle of such a nature that each tube will only fit its appropriate connection. Several deaths have resulted during the use of the older form of apparatus from chloroform being injected into the patient's larynx through the nasal tube. This nasal tube—a flexible tube like a catheter—may be replaced by a metal mouth tube shown in fig. 44, C. *The apparatus should always be tested before use to ensure the proper arrangement of the tubes.*

When chloroform is administered for operations about the mouth or nose, *e.g.*, removal of an upper jaw, the tongue, etc., the anæsthesia, having been obtained by chloroform, is best maintained by fitting the efferent tube of a Junker's inhaler (*i.e.*, the tube not connected with the bellows) over a catheter, and, either passing the catheter through the nostril so that the end hangs down behind the soft palate and permits the vapour to enter the larynx, or else holding the catheter in the mouth. When a preliminary tracheotomy has to be done and a Trendelenburg's or Hahn's tube is used, the catheter may be held over the external opening of the

tube, and chloroform vapour so allowed to enter the trachea.

Another plan is to connect the tube with the gag (Hewitt) and pump the vapour into the mouth.

Junker's inhaler has been modified by Messrs. Krohne and Sesemann, the original makers (fig. 44). The bottle and tube remain the same, but in the latter an obstruction is made between the foot or hand bellows

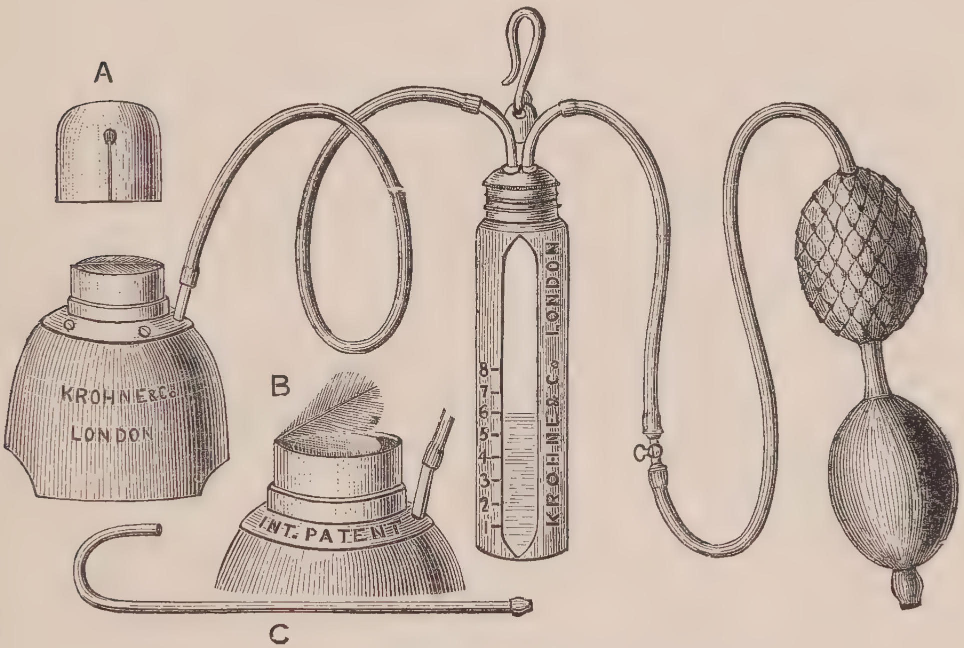


FIG. 44. Krohne and Sesemann's feather respiration register.

and the bottle, by which means the intermittent jerky delivery of vapour is changed to a continuous supply. The face-piece is replaced by a Skinner's mask (see fig. 45) so constructed that the chloroform vapour escapes by a series of holes in the midrib of the frame. The frame is covered by a removable flannel cap. By this contrivance the face-piece is pervaded with vapour instead of a puff of chloroform being intermittently propelled

against the face, as in the old apparatus. The advantages of the flannel cap are (i) its permitting free breathing through its substance, (ii) the patient obtains a free air supply, and further, the administrator can, by placing his hand over the mask, feel whether or not a sufficient blast of air is being expired. It is cleanly, as it can be removed easily and washed.

The feather seen in fig. 44 at B is intended as a guide to the administrator, its movements being a register of the expirations and inspirations of the patient. I think it is not wise to trust to any mechanical test of respiration, however ingenious; I therefore prefer to use either the glass mask or flannel cap. Mr. Krohne has further elaborated the apparatus so as to permit great dilution of the vapour. Thus with the most recent pattern of the inhaler ♏ $\frac{1}{20}$ can be given and the dose gradually increased. This is effected in the following way. The afferent or air tube, instead of being provided with one compression and one resistance ball as in Richardson's bellows, has three india-rubber balls of different sizes placed at the hand end of the tube. These are made of such capacity that known quantities of air are propelled into the chloroform bottle, according as the large, medium, or small ball is squeezed in the hand. This contrivance is of course only approximately accurate. The actual amount of chloroform taken up by the air which traverses the chloroform bottle will be influenced by the depth of the chloroform in the

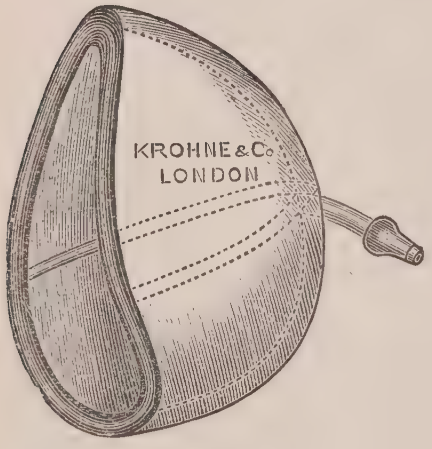


FIG. 45. Flannel cap for use with Krohne's Junker inhaler.

bottle, the rate of compression, and the temperature of the room.

Methods, when a dosimetric apparatus is not used.—Many persons prefer to rely upon simpler methods in giving chloroform. The obvious disadvantage of such plans is that even the most expert cannot tell what percentage of chloroform the patient is taking, and must rely solely upon the effects of the anæsthetic on the patient as observed by him. Thus, although the expert chloroformist may employ such a method without grave risk, one less experienced is liable to give too much or too little of the anæsthetic, being at times either unobservant, or unable to understand the meaning of such changes in the patient's condition as he may notice.

The usual methods employed may be described briefly as the "Scotch," the Hyderabad (which is a convenient adaptation of the first-named and especially useful in hot climates), and the plan of dropping chloroform from a drop bottle upon a mask or improvised face-piece.

The Scotch method was described by Simpson in the following words :—

"When used for surgical purposes, perhaps it will be most easily given upon an handkerchief, gathered up into a cuplike form in the hand of the exhibitor, and the open end of the cup placed over the nose and mouth of the patient. For the first inspiration or two, it should be held at the distance of half an inch or so from the face, and then more and more closely applied to it. To ensure a rapid and perfect anæsthetic effect—more especially when the operation is to be severe—one or two teaspoonfuls of the chloroform should be at once placed upon the hollow of the handkerchief and immediately held to the face of the patient. Generally a snoring sleep speedily supervenes; and when it does so, it is a perfect test of the superinduction

of complete insensibility. But a patient may be quite anæsthetic without this symptom supervening." *

Lord Lister thus describes the Scotch method:—A common towel is arranged so as to form a square of six folds, and enough chloroform is poured upon it to wet an area the size of a hand's palm, the precise quantity poured on not being a matter of any consequence. The patient is instructed to close his eyes to protect them from the irritating vapour, and the towel is then held as near to the face as can be borne without inconvenience. More chloroform is added from time to time as occasion requires. Lord Lister suggests the following simple way of devising

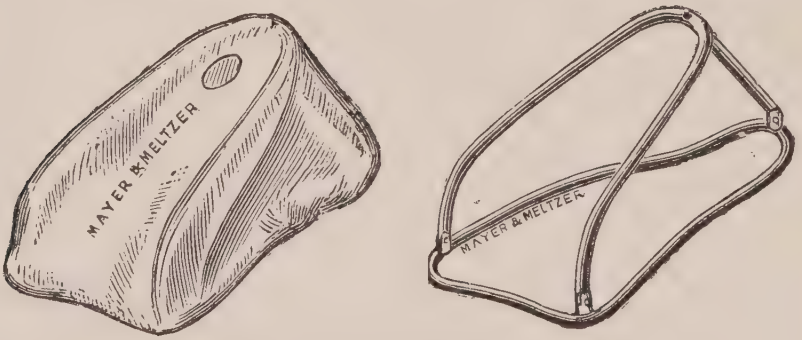


FIG. 46. Frame for chloroform.

a chloroform mask:—The corner of a towel pursed up systematically into a concave mask to cover the mouth and nose, by pinching it together at such a distance from the corner that, when the pinched-up part is held over the root of the nose, the corner extends freely to the point of the chin. "The cap formed in this manner being so arranged upon the face, chloroform is gradually dropped upon it till the greater part of it is soaked, the edges being left dry to avoid irritation of the skin by the liquid, and the moist condition is maintained by frequent dropping on the convex surface until the requisite physiological effects are produced."

* Simpson's "Anæsthesia," p. 159.

The method in which a drop bottle is employed requires either the use of an extemporised inhaler, such as that suggested by Lord Lister, or of a mask. Those described below are the best known.

Masks.—The Skinner's mask figured above (fig. 46) is the most usual form. It consists of a wire frame on which is stretched flannel, domett, or lint. The chloroform is allowed to fall *guttatim* upon the upper surface.

An excellent form of mask is due to Schimmelbusch. It consists of a metal frame on which are fixed two bent semi-circles at right angles. These fit into the frame when

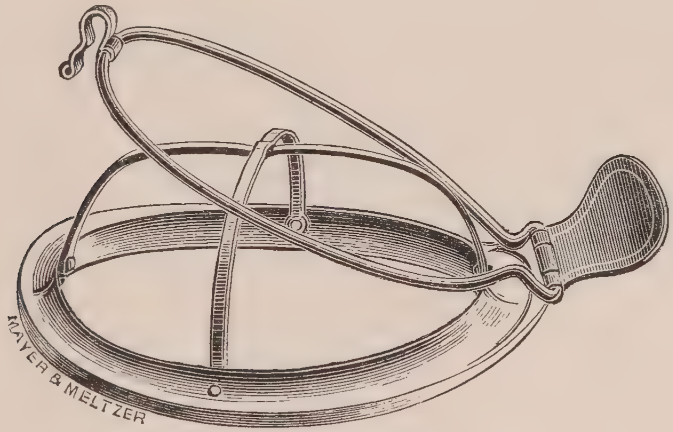


FIG. 47. The Schimmelbusch mask.

not in use, but when used, open out and form a cup over which is stretched a piece of lint kept in position by the hinged rim, which is attached to the frame. It is used with a drop bottle, or chloroform sprinkled over it.

The Hyderabad cone, as devised by Dr. Lawrie (fig. 48), is essentially a calico mask with some cotton wool in its apex and its sides strengthened by thin strips of wood. Into this two drachms of chloroform are poured, and the mask held a little way from the face until the patient is accustomed to the vapour, and his nervousness has passed away. The mask is then brought gradually nearer to the

face. Chloroform is poured on from time to time as required. To do this the cone is inverted and a drachm of chloroform poured into it. The breathing must be most carefully watched, and if any interference with its rhythm occurs the mask must be at once removed, and when the breathing resumes its natural character the cone be again gradually brought into position. Care must be taken that chloroform is not dropped on the skin of the face, or into the eyes.

The administration.—Whatever method is em-

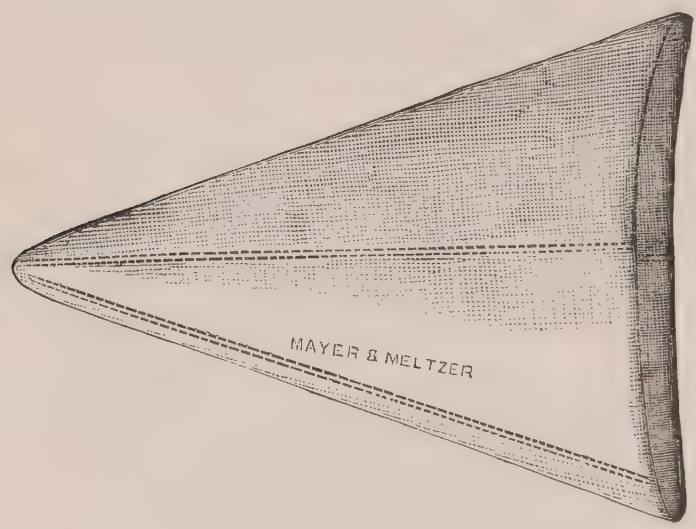


Fig. 48. Hyderabad cone.

ployed the same result is aimed at, and the rules guiding the administrator, as well as the phenomena shown by the patient during inhalation, are so essentially similar that it is proposed to consider the course of narcosis under chloroform in general, only noting such special points as may need further elucidation.

The patient should be carefully prepared, for this is perhaps even more important in the case of chloroform than in that of any other anæsthetic. Vomiting nearly always occurs during the induction of anæsthesia when

the stomach contains food, and when the bowels have not been properly regulated. Associated with it are lowering of the blood pressure and increased liability to syncope.

Posture.—The patient must be placed recumbent, with all his clothing absolutely loose. The sitting posture was believed by Snow to be a safe one for chloroform narcosis, but in view of our present knowledge it seems highly important that, even for short operations, the chloroformist should insist upon the recumbent posture. Whenever the exigencies of the operation permit, the head should be placed at a lower level than the abdomen. In the first degree of narcosis the head may be allowed to be somewhat higher, as most persons, more especially the stout, feel uncomfortable and may find breathing difficult if the head is very low. The pillows must be so arranged that the head is slightly extended upon the trunk, never flexed with the chin resting upon the breast. Over-extension tends to cause dropping of the chin with falling back of the tongue, while extreme flexion interferes with natural respiration. When the second degree of narcosis is reached, the head should be lowered and the face turned to the side.

The inhalation.—The patient, having been reassured by a few words and directed how to breathe, begins to inhale. In whatever manner the chloroform is given, whether from an inhaler, or from a Skinner's or other mask with a drop bottle, or by the open method, the greatest care must be taken to give a very dilute vapour at the commencement of the administration. Coughing, holding the breath, struggling, nearly always arise from too strong a vapour being presented to the patient. Soon the strength of the vapour can be increased. The patient becomes restless, talks nonsense, tries to move. The pupils gradually dilate but the eyeballs roll from side to side.

As the stage of excitement becomes more pronounced the breathing must be carefully watched. The amount of excitement shown varies, not only with the individual patient, the strong and muscular evincing most, but also with the method employed. With dilute vapours, for example, when the Vernon Harcourt regulator is used, the excitement stage is usually very brief and ill-defined or absent. Even when no previously known obstruction exists, such as nasal stenosis, buccal growths, enlarged tonsils, pharyngeal or laryngeal tumours, interference with respiration during inhalation may occur from spasm of the masseters, closure of the lips, laryngeal spasm (see Complications), epistaxis, vomiting, falling back of the tongue, or fixation of the chest by muscular spasm. If the obstruction is in the upper air-passages, opening the mouth with a gag or separation of the lips with the finger will usually enable the patient to take one or two inspirations, which will probably tide him over the period in which muscular spasm exists. The mouth and upper pharynx must, of course, be examined with the finger, if there is any reason to expect the presence of foreign bodies in the buccal cavity. In opening the mouth take care, if spasm exists, not to break or displace loose teeth, especially while using Heister's mouth opener. As a rule the finger inserted behind the teeth will force open the jaws sufficiently for the insertion of a wedge or gag. In the stage of excitement the chloroform should be pushed, provided respiration is unimpeded and regular, but, as throughout the inhalation of chloroform, interference with breathing must be met by withdrawing the chloroform until the breathing is again normal. The excitement passing off, rigidity of the muscles may persist for a short time, although the loss of lid reflex and fixation of the eyeball with a contracted pupil evidence the passage into the third degree,

or true anæsthetic stage. This muscular rigidity eventually passes off; some muscles, however, *e.g.*, the recti abdominis, often remain rigid for a considerable time, especially if any excessive deprivation of air has been allowed during the induction. The breathing is now regular, sometimes a soft snoring is heard, but no noisy stertor should exist. Its presence is evidence of obstructed breathing and its cause should be sought and removed. The administrator should notice whether expiration is fully performed and whether there is any duskiness about the face or ears. **Cyanosis, however slight, is to be avoided;** it is caused by excessive quantities of chloroform and failing respiration. As soon as the patient is in the true anæsthetic stage the amount of chloroform must be lessened and only so much be given as is required to maintain anæsthesia. Young children often appear to have passed into this degree of narcosis when merely asleep, but if the progress of the case has been carefully observed, no mistake need be made. A watch kept on the respiration, the colour of the patient, and the condition of the **pupils** and **eyeballs** will enable the administrator to keep his patient anæsthetic, without deepening the degree of narcosis. During the induction the eyeballs move; the pupils react to light and gradually dilate. During the stage of excitement the dilatation becomes more marked. In the stage of true anæsthesia the eyeballs are fixed, and the pupils gradually contract, but remain sensitive to light; the lid reflex disappears. In the fourth degree the eyeballs are rigidly fixed, slightly rotated upwards, the pupils dilate and are insensitive to light. This dilatation reaches its acme as death occurs in the fifth degree of narcosis. The early signs of **returning consciousness** are, moving eyeballs with dilating pupils, return of the lid reflex, and, if vomiting is about to occur, the patient swallows air, grows pale, and

respiration becomes weak. On the other hand, the signs of **deepening narcosis** are duskiness or pallor, dilating pupils with a fixed eyeball, flaccidity of the muscles, weakened respiration, and soft feeble pulse.

The pulse, although a valuable sign of the *general condition* of the patient, is no guide by itself of the degree of narcosis. In cases in which much shock and hæmorrhage are present, the narcosis will rapidly deepen, even although no increased supply of chloroform is being given. This arises from the fact that the nervous system when drained of blood is more readily narcotised.

The degree of narcosis must be deepened or the reverse, according to the strength of the patient and the nature of the operation. Incomplete and inadequate degrees of anæsthesia are in themselves a source of danger, and when a patient is very lightly under chloroform there is always a risk lest the administrator should maintain a seesaw between excessively slight and unduly deep narcosis. Irregular breathing, and a tendency to strain, cough, or vomit commonly appear under these circumstances, and the administrator is tempted to obviate such inconveniences by suddenly presenting a greatly enhanced strength of chloroform vapour. This, under such circumstances, is tolerably certain to lead to overdosage and danger. A full and continuous anæsthesia should be aimed at, and to effect this it must be borne in mind that the intake of the anæsthetic should be equal to the amount exhaled by the patient. During the early part of the induction more chloroform enters than is expelled by expiration. In true anæsthesia about the same amount enters as is given off, and as soon as the percentage strength is lessened the quantity expired will exceed that inspired. This should occur steadily as the anæsthesia is maintained, since very much less chloroform, or rather a much lower percentage of

chloroform vapour, is needed to prolong anæsthesia than is necessary to establish it. While undue haste is always dangerous, excessive slowness in the induction of chloroform narcosis is also undesirable, as there is a proneness to sickness, and with it a fall of blood pressure which often induce extreme depression, or syncope. The time occupied in the induction varies considerably. The peculiarities of the patient, and the method may delay or hasten the onset of anæsthesia. Five to ten or even fifteen minutes may be required. Besides the loss of conjunctival reflex, it is wise to ensure regular easy breathing, a good colour, and a relaxation of the muscles before the operation is commenced. In abdominal operations this is extremely important and an extra few minutes are well spent in obtaining such a result. If the induction is hurried and anæsthesia barely obtained, the commencement of the operation will cause the patient to pass back rapidly into lighter narcosis, the breath will be held, and the respiration become irregular. It will under such circumstances be extremely difficult to obtain a satisfactory anæsthesia throughout the operation.

It is very important to appreciate the fact that incomplete narcosis, *i.e.*, below the third degree, is undesirable, if not dangerous, at the period at which an operation is commenced; yet when a patient has once been taken through the third degree and is truly anæsthetic, he may safely and satisfactorily pass back into the second degree during the subsequent conduct of the operation.*

Recovery from the Effects of Chloroform.

Of persons who pass easily under chloroform, and who have taken only a small quantity, the recovery is

* The use of the nasal or mouth tube is described on p. 218 and in Chapter IX.

marked by few noticeable symptoms. They awake as from sleep, are sometimes sick, or feel slight nausea, rarely complain of the persistence of the taste or smell of the vapour, and are prone to sleep. Snow states that persons become conscious in ten minutes after ceasing to inhale. Old people are slowest to awaken. To all patients, and especially to the weakly, and to those who have gone through a severe operation where much blood loss or shock was present, owing to the fall of blood pressure and the ischæmia of the cerebral circulation, syncope is a grave danger. Sudden sitting up, as in the act of vomiting, even lifting a patient, may cause faintness. Numerous deaths have been reported after chloroform inhalation, owing to the patient having been put back to bed and left unwatched. The patient in these cases has been suffocated, either from malposition of the head, or through vomiting having taken place and the vomitus entering the air passages.

Difficulties arising during the induction of chloroform anæsthesia.—Nervous persons and young children commonly hold their breath, or breathe so softly that they inhale insufficient vapour to establish anæsthesia within a reasonable time. This is usually the result of commencing with too strong a vapour. If the anæsthetic is taken away entirely, the patient will resume his usual breathing and the chloroform can be given again, only more gradually. Breath-holding in the semi-unconscious state arises reflexly and from the same cause and may be remedied in a like manner.

I have met, however, with powerful men who while in the second degree held their breath and struggled, repeating the process at each attempt to give them chloroform. This condition is obviously dangerous, as any attempt to push the anæsthetic leads to disaster. It can be overcome by giving ether freely for a few inspirations. All air

is excluded, the patient is held and a few compressions of the thorax are made with one hand. As soon as respiration is well started, chloroform can be substituted for the ether. Struggling, although frequently due to too strong a vapour, especially quite at the beginning of the administration, may arise from other causes not associated with overdosage. In the highly nervous, the neurotic, and especially in the alcoholic, the condition is common and pronounced. Unless the administration is being conducted by an accurate apparatus, which enables the chloroformist to lessen his percentage to one per cent. of vapour, the chloroform must be at once withdrawn until the breathing has resumed a regular rhythm. It is then to be given again, but more sparingly. Breathing may grow more and more shallow: pallor may appear due to interference with the circulation. This alarming association of symptoms is not infrequently seen in children and feeble subjects. Its cause may be some slight interference with the breathing, such as sucking back of the tongue, falling of the jaw, mucus collected about the laryngeal aperture, or epistaxis, and attention to the cause and its removal may be all that is required. But in asthenic and especially in anæmic patients the origin of the trouble is more usually a feeble state of the heart. If the head is placed at a lower level than the trunk, the symptoms will disappear and the induction will pursue a normal course. Retching and even vomiting may occur as a patient begins to inhale. When there is no question of food being in the stomach, or of regurgitation of intestinal contents, as in cases of obstruction, increasing the supply of chloroform and pushing forward the lower jaw rhythmically will usually succeed in preventing vomiting. When food or intestinal contents are vomited the chloroform should be withdrawn, the head kept low and turned to one side. Care must be taken by

swabbing out the mouth to prevent aspiration of the vomit into the air-passages. It is best before recommencing the chloroform to request the surgeon to have the stomach washed out. This is seldom necessary, however, in the case of young children. When the patient is anæsthetised, care must be taken that he is moved and shaken as little as possible, nor must he be exposed to draughts or any conditions which will chill his body.

An extremely important point to bear in mind is that, although the loss of conjunctival reflex is regarded as the criterion of true anæsthesia, yet many surgeons require a more profound narcosis than exists at the time this reflex disappears. Undoubtedly deepening narcosis is in all cases fraught with danger, and the administrator who has to bring this about must be sensible of the risks and watch the signs of deepening narcosis with the utmost care. The relaxation of the recti muscles in strong athletic adults, and the slow shallow breathing which are often considered necessary for the proper performance of abdominal operations can only be obtained by increasing the dose of chloroform to a point when the medullary centres are profoundly under the influence of the drug. At this stage any interference with respiration, or the occurrence of hæmorrhage, may lead to enfeeblement or cessation of respiration. The blood pressure, which is greatly lowered when the patient is profoundly anæsthetised, is also liable to fall still more, and in so doing to impair the coronary circulation.

Persons of different physique require different amounts of chloroform, and the requirements of operations also call for a like variety of treatment. It will be found that these variations apply especially to the period of induction, but in the later phases of the administration similar laws hold good. Thus the feeble and those who are profoundly shocked

will need very little anæsthetic to maintain anæsthesia; the vigorous and alcoholic will require large doses to keep them relaxed and without movement. Since the severity of the after effects is directly due to the amount of the anæsthetic which the organism has to eliminate, it is necessary to limit the quantity given as much as the exigencies of the operation and of the individual will permit.

As to the incidence of **danger,** it may be fairly stated that the strong and athletic are, if anything, more liable to accident than the feeble. No age or temperament is free from possible peril, nor can it be accepted as truth that a person who has many times taken chloroform with impunity therefore enjoys an immunity from its risks. Chloroform, like any other drug, produces effects according to dosage, and there is little doubt that for most persons the dose is determined by their body weight and physique. It is possible, nay even probable, that the resistance evinced by some patients is peculiar to themselves. Just as minute doses of potassium iodide, or other drugs, will cause great inconvenience to certain people, so even small amounts of chloroform will produce much greater physiological effects upon some persons than upon others. It is this which renders it necessary to commence the administration of chloroform with caution, and only augment the dose when it has been ascertained how the patient reacts under its influence. Nor can it be too strongly urged that only by constant observation of the phenomena and a right interpretation of their significance will safety and success be ensured. The guides are first and foremost **respiration,** which must be studied, not only by watching the thoracic movements, but also by noting the force of expiration. This is best done by placing the hand over the patient's mouth from time to time. The colour of the face, lips, and ears will give a fair indication of the state of the blood

pressure, and the ocular phenomena indicate the depth of narcosis. In the early degree the conjunctival reflex is brisk, the pupils are moderately dilated, and the eyeballs move more or less slowly. In the third degree—the stage of true anæsthesia—the conjunctival reflex is abolished, the eyeballs cease to move, and the pupils contract and may be reduced to a pin's point. Deeper narcosis, when the patient is passing into the fourth degree and the medullary centres are becoming overdosed, is shown by gradual failure of respiration, most marked by the feebleness of expiration, by dilatation of the pupils and loss of the light reflex. It should be remembered that the conjunctival reflex disappears before the corneal reflex, and that the latter therefore signifies a profound state of narcosis and one which is very near the zone of danger.

Complications arising during the administration of chloroform and their treatment:—

Interference with Respiration.

This may arise from Mechanical Causes, or result from the direct action of chloroform upon the Respiratory Mechanism.

The symptoms evoked will depend upon the extent to which the patient's breathing has become hampered, and the treatment will vary according to the cause.

1. **Mechanical.**—The falling together of the arytæno-epiglottidean folds occludes the larynx, and interferes with inspiration. It is an extremely common accident, and if not observed and remedied may become very serious. The patient's breathing becomes irregular

and harshly stertorous, the chest movements are not interfered with, the face grows dusky, and this is seen especially in the ears and lips. Respiration then ceases, and the patient's face becomes black.

The tongue may fall back and so occlude the laryngeal opening. When the patient is deeply under the anæsthetic the lower jaw and with it the hyoid bone drop, and the tongue is carried back so as to close the laryngeal chink. The air is thus prevented from entering the lungs, as every inspiratory effort only sucks the epiglottis back. It thus acts as a valve permitting some expiration but no inlet of air. The movements of the chest still persist, although practically no air is entering. As asphyxia is developed the movements become irregular, and finally cease. Usually, but not always, snoring stertor is present under these circumstances. The signs of asphyxia are soon seen, the face becoming dusky, then blue, and finally a mottled black, the pulse weakens, and unless promptly relieved the patient dies.

MUCUS, or BLOOD CLOT, or other fluid, may sometimes collect over the upper opening of the larynx, and in persons whose respiratory efforts are not vigorous may cause suffocation. Insufficient air exchange leads to signs of asphyxia more or less pronounced, the most striking of which is the progressive duskiness of the patient's face. In this case the throat should be sponged out and the chin jerked up, a manœuvre often sufficient to dislodge the obstruction and restore normal respiration.

Entrance of foreign bodies into the larynx or trachea.—Teeth, natural or artificial, portions of bone, blood clot, pus, vomit, nasal polypi, masses of new growth, gags, sponges, may drop back and enter the air passages, or, in the case of solids, may become jammed in the œsophagus, and so provoke asphyxia by

mechanical pressure. Small or soft substances which enter the larynx may set up spasm and so prevent passage of air, or they may pass into the trachea, or bronchi, and produce urgent dyspnœa and suffocation. So long as the coughing reflex persists foreign bodies will not, as a rule, pass the vocal cords, but in deep narcosis this safeguard no longer exists. It is, therefore, better to employ light anæsthesia in operations upon the buccal cavity and upper air passages, in order to avoid the danger of suffocation through foreign substances or liquids entering the lungs.

Treatment.—The falling together of the arytæno-epiglottidean folds and falling back of the tongue are less liable to occur if the head is placed on the side, so that the weight of the tongue does not tend to drag it backwards. Of course, every precaution should be taken to avoid the danger of foreign bodies being aspirated into the lungs. If a post-pharyngeal or tonsillar abscess has to be opened, the pus and blood must be sponged out of the mouth. All loose teeth and masses of growth should be noted, and if possible removed or guarded. When the position of the head has been adjusted, and the other precautions mentioned have been taken, any interference with breathing, or duskiness of colour will attract attention. If they occur the mouth must be opened. In some cases this is difficult, as the asphyxial condition causes spasm of the muscles, and the jaws become firmly set. A gag, or mouth opener, can sometimes be introduced in a gap between teeth, and failing this it may be necessary to force out a tooth in order to introduce the mouth opener. When the mouth is opened the tongue should be grasped with forceps and pulled forcibly out of the mouth, while any foreign body which is seen to have fallen back over the opening of the larynx is seized with forceps and removed.

In the case of blood, mucus, or other liquid, sponging out the back of the pharynx will remove the cause of the dyspnœa. The tongue should be dealt with without roughness. If diseased, and force is suddenly applied, the tongue may be torn, and even if healthy its under surface will be badly cut and lacerated, unless care is taken to avoid its being stretched forcibly over the lower incisors. In many persons the upper teeth articulate in front of their opponents, and pushing forward the lower teeth will fail to carry the tongue clear of the glottis. It is, however, only necessary under these circumstances to depress the lower teeth by opening the mouth, and then to carry them forward until they are in front of the upper incisors. When this is done the pushing forward of the lower jaw by the finger applied behind the angle will keep the air passages open.

When suffocation is being caused by spasm of the larynx, its relief must at once be obtained by performing tracheotomy, and by sucking out blood clots, masses of growth, etc.*

In any of these conditions, if respiration has actually ceased, it will be necessary to perform artificial respiration as soon as the cause of the obstruction to breathing has been discovered and removed.

Inversion is also of value in cases when it is feared that blood has entered the windpipe. After tracheotomy, sucking the tube is usefully supplemented by inversion.

Insufflation of the lungs by means of a catheter passed through the larynx has been recommended, but it would

* An instructive case occurred under my charge at University College Hospital. A man from whom the upper jaw had been removed by Mr. Christopher Heath was under operation for a recurrence of epitheliomatous growth, when his respiration suddenly became hampered, and signs of impending suffocation appeared. Tracheotomy was promptly performed, the tube sucked, and several small masses of the growth withdrawn from the windpipe in this way. The man's breathing was restored, and the operation was completed.

appear less effectual than tracheotomy and artificial respiration, aided, when need be, by sucking out blood or mucus from the tracheal opening. Catheterising a bronchus has, it is stated, saved a patient's life when other means had failed. If the foreign body has passed through the larynx and is lodged in a bronchus, it is best, unless asphyxia is imminent, to avoid a hurried tracheotomy. Subsequently a formal operation for the removal of the tooth, or whatever it may be, can be undertaken deliberately and with antiseptic precautions.

2. Asphyxial conditions occurring during the inhalation of chloroform, and due to other than mechanical causes, are of the greatest importance. While many authorities have contended that in such complications alone lie the dangers of chloroform, all admit their constant occurrence and extreme peril. Although, as Snow pointed out, actual deaths from failure of respiration without initial interference with circulation are few, yet accidents from interference with respiration are very common and prove fatal unless recognised, as they should be, and promptly dealt with. Further, resuscitative measures, unless very long delayed, prove successful in most instances of respiratory failure under chloroform.

When chloroform is presented to the patient in **too concentrated** a vapour, **forced holding** of the **breath, struggling** and even **spasm** of the **glottis,** may result. There is usually violent struggling, the pupils are widely dilated, and the face wears an expression of terror, cyanosis rapidly deepens, and the respiration suddenly ceases. It is sufficient to withdraw the anæsthetic, and when respiration is resumed to give it again more diluted and more guardedly. It should be adopted as a rule, that any of the above symptoms demand the withdrawal of the anæsthetic. If, in a deeper degree

of narcosis, the vapour of chloroform is allowed to be stronger than can be eliminated, the amount absorbed into the blood gradually increases, and the patient passes into the fourth degree of narcosis (Snow), weakening of the respiration and duskiness of the skin and mucous membranes ensue, without any warning symptoms except the increasing enfeeblement of respiration. Finally, respiration stops. But this result may arise more suddenly when a patient, already deeply under the anæsthetic, is made to breathe a fresh and inadequately diluted supply of chloroform; the medullary centres then become rapidly over-narcotised and respiration ceases. These forms of respiratory failure are especially liable to occur in individuals suffering from pre-existing respiratory disabilities, *e.g.*, the anæmic, the cyanotic, the emphysematous. Persons who suffer from some condition which interferes with respiration are liable to have their breathing rendered still more difficult as they pass under the influence of chloroform. In cases of cerebellar tumour, spinal disease affecting the upper dorsal and cervical regions; in cases of thoracic disease when one or both lungs are interfered with, such as hydrothorax, œdema of the lungs, or empyema thoracis; and in cases of abdominal tumours when the upward pressure embarrasses breathing, a very small amount of chloroform will actually cause arrest of respiration. There is another type of patient who incurs a similar risk. The danger arises from obstruction in the upper part of the respiratory tract such as may arise from inflammatory swelling in the cellular structures of the neck, masses of glands, œdema, or abscess pressing upon the trachea, and goitre. As in the other class of cases to which reference is made above, very small quantities and low percentages of chloroform may prove fatal through interference with respiration. It should be borne in mind that in these cases a vicious circle soon

establishes itself. The initial respiratory difficulty leads under chloroform to venous congestion, and this in its turn causes still further interference with breathing.

Treatment.—If the respiration is closely watched and inspiration and expiration are seen to be natural, most of the dangers mentioned above will be avoided. Any deviation from the normal breathing should be observed and adopted as a guide as to whether more or less chloroform should be given. When respiration becomes ineffectual or ceases, the chloroform apparatus must at once be taken from the patient's face, the head extended on the trunk, the tongue drawn *out of the mouth,* and artificial respiration by the appropriate method practised. If fluid is in the lungs the Marshall Hall plan should be adopted, in other cases Sylvester's or Howard's method may be used.* The movements must be made deliberately and accurately, and extreme care taken to perform them synchronously with any slight chest movement which nature is able to make. When the patients have a rigid thorax, compression of the abdomen with the view of emptying the lungs by forcing up the diaphragm is an aid to artificial respiration which should not be neglected.

For young children and persons whose ribs are easily compressed, the lateral decubitus may be adopted. The hands of the anæsthetist are then so placed as to grasp the upper side of the thorax. Rapid compression and relaxation are then practised, and air is thus made to enter and leave the thorax.

Professor Wood assures me that since he has adopted "forced respiration" he has never seen any fatalities under chloroform. Many apparatus for perflation of the lungs have been invented; perhaps Fell's is the best. A tube

* In appropriate cases Schäfer's method should be adopted in preference to the others. These methods are described in Chapter X.

introduced into one nostril and connected with a powerful foot bellows will easily fill the lungs.* In cases of threatened death from respiratory paralysis I have perflated with oxygen in this manner, or directly through the larynx, and have restored some cases which appeared quite hopeless until I had adopted this measure. Strychnine injected hypodermically (gr. $\frac{1}{60}$ to $\frac{1}{30}$ or even $\frac{1}{10}$) is a valuable adjuvant, but is ineffectual unless artificial respiration is vigorously kept up while the strychnine is absorbed. Hobday suggests hydrocyanic acid as an antidote to chloroform; but the plan has not been used upon human beings, and is probably not devoid of danger.

(See Chapter on Accidents of Anæsthesia.)

Failure of Circulation.

Syncope.—Failure of the heart may occur quite at the commencement of the administration (primary cardiac syncope), that is, after two or three inspirations of chloroform vapour, or it may supervene much later—in the third degree. In the early degree of narcosis, syncope has been variously accounted for; it has been attributed to reflex inhibition of the heart excited by terror, or by the irritation, by the chloroform vapour, of the sensory nerves of the pharyngo-laryngeal mucous membrane and pulmonary tract; or to an individual obnoxiousness to chloroform, vaguely called the "chloroform idiosyncrasy." Cases have been recorded of sudden death, provoked by fear, in persons about to be operated upon, who have either taken no anæsthetic, or have imagined, erroneously, they were being chloroformed, while in reality they were

* Great care must be used not to rupture the air vesicles by undue vigour in perflating the lungs by means of the bellows.

inhaling eau de Cologne, or an equally innocuous vapour. Persons may, and no doubt do, faint when about to take an anæsthetic, from apprehension. Many deaths have occurred from this cause, so it must not be ignored when considering the perils during anæsthesia, although the anæsthetic may have no direct causal relation to the fatality. It is unquestionably highly important that all perturbing causes provocative of fear, such as loud and technical talking descriptive of the horrors of the operation, should be carefully avoided in the patient's presence. No movement, such as uncovering the field of operation, suggestive of the commencement of the operation, should be permitted until unconsciousness is well established. Fear and trepidation must always be met by kindly reassurance, while haste and brusque handling should be studiously avoided. The commencement of the operation before complete anæsthesia has been induced is certainly liable to cause syncope by reflex inhibition of the heart.

The imperfectly chloroformed patient is furthermore prone to syncope. It seems probable that inhibition of the heart takes place as a result of stimulation caused by cutting the skin, especially over a sensitive area, and this stimulus is communicated along sensory nerves whose conduction is not yet in abeyance. Records of death in a state of incomplete anæsthesia show how often the fatality arises in cases when trivial, although painful, operations, such as reduction of dislocated limbs, circumcisions, etc., are being performed. During incomplete anæsthesia, the heart is peculiarly liable to reflex inhibition, since the excitability of the vagi, as Embley has shown, is increased in the early degrees of narcosis, and so brings about a rapid fall of blood pressure, which may prove fatal before the heart escapes from the vagal inhibition.

Symptoms.—Extreme and ghastly pallor, with some

blueness of the ears and finger-tips, wide sudden dilatation of the pupils, fluttering feeble pulse, and cessation of respiratory movements and of all perceptible heart movements usher in this syncope. There is little or no warning, nor can the most careful preliminary examination give an indication of cases in which this danger is likely to occur. Persons the subjects of fatty degeneration of the heart, of aortic or advanced mitral disease, are always liable to syncope, but the robust and vigorous incur a like risk, and are sometimes the victims of syncope occurring in the initial stage of taking chloroform. Syncope may occur at other stages of chloroform narcosis (secondary cardiac syncope), but in these cases there is commonly more warning; there is a gradual failing of the heart, evidenced by weakened and often intermittent pulse, pallor, cyanosis, cessation of hæmorrhage; and dilatation of the pupils, with failure of respiration. The cause of syncope, if we exclude surgical shock, hæmorrhage, sudden change in the posture of the patient's body, is probably always an excessive strength of the chloroform vapour. I have never seen it occur when 2 % was being breathed, although I have seen reflex interference with circulation with this strength of chloroform. With percentages above 2 syncope is not uncommon, and is usually FATAL when STRONG VAPOURS are in use.

Treatment.—Chloroform inhalation must be at once stopped, the patient placed so that his head lies at a lower level than his feet, and when possible his legs should be raised, in order to assist the return of blood to the heart and brain. Complete inversion of the patient as practised by Nélaton is certainly the most important remedial measure we possess, but should never be employed when asphyxial complications co-exist with the syncope. The respiration, which will have ceased coincidentally with

the cessation of the heart's action, must be kept up by the artificial respiration methods of Howard and Sylvester (see Chap. X.). When syncope is presumably the result of the fall in blood pressure producing bloodlessness of the medulla oblongata, the blood being collected in the abdominal veins, inversion would, it is pointed out by Leonard Hill, have the effect of still further filling the right heart. He suggests that placing the patient in the feet down position for a moment while the chest is compressed, should help the right heart to expel its blood and fill the arterial system so that, when the patient is again inverted, arterial blood will find its way to the central nervous system and heart, and so promote their functions. He further insists that if need be the manœuvre should be repeated. Hill's views are supported by sound physiological data which are undeniable. I have had, however, no opportunities of verifying his results. There would seem to be some risk in raising the head of a patient, but possibly this danger is less than that of inversion if, as Hill insists, the blood cannot pass the heart and reach the nervous centres until the right ventricle is relieved of its distended condition by gravity.

When, in performing artificial respiration, the thorax is grasped in expiration, it is well to slip the hand under the costal border on the left side, and so mechanically excite the heart, a method which Koenig has shown to be valuable. The chest and throat, bared of all clothing, should be slapped with a towel wetted in cold water, and fresh air from an open window allowed free access to the patient. Hypodermic injection of strychnine, although of more value when the respiratory centre is at fault, is a valuable method in all cases of chloroform poisoning. As much as gr. $\frac{1}{10}$ has been given in bad cases, but gr. $\frac{1}{30}$ is usually the dose adopted, although

it need hardly be pointed out even this is a large dose of a powerful remedy. Dr. Crile, who has made an experimental examination of surgical shock, asserts that strychnine is useless in small doses, and in large ones may increase the fall of blood pressure and so do actual harm. Digitaline is probably a more efficient remedy, although it is less a respiratory excitant than is strychnine. The injection of brandy in *hot* beef tea or in warm saline solution by the rectum is a useful measure.

Maas recommends rapid percussion with pressure over the cardiac area. He compresses 100 or 120 times in a minute. Laborde's method of rhythmic traction upon the tongue finds many advocates. The tongue is seized and dragged forwards out of the mouth as far as possible, it is then allowed to fall back, and again brought forward, the manœuvre being repeated 16 to 20 times a minute, or even more rapidly. Manskowski advocates and has successfully used intravenous injections of sterilised freshly prepared **supra-renal extract.** Schäfer regards supra-renal extract as the most powerful constrictor of the vascular system we possess, and places it with nicotine in the front rank among restoratives in cardiac syncope. The best way of employing this drug is to mix 1 or 2 drms. of the 1 in 1,000 solution **Adrenalin** in a pint of normal saline * and inject into a vein or into the subcutaneous cellular tissues.

The inhalation of **nitrite of amyl** is vaunted as a specific, and certainly I have seen it do good in cases of syncope occurring late in narcosis, or after an operation when much blood-loss had occurred. The most convenient way of using the drug is to break a ♏iij. glass capsule

* Normal saline is 7% sodium chloride in sterilised water, *i.e.* 1½ drms. to the quart. Dr. Hare (*Practical Therapeutics*, 1905, p. 537) recommends the following: Calc. Chlorid. 0·25, Pot. Chlorid. 0·1, Sod. Chlorid. 9·0, Sterilised Water 1,000 c.c.

and hold it beneath the patient's nose, taking care that artificial respiration is maintained so as to ensure the due entrance of the vapour into the lungs.

Among other measures advocated for counteracting this syncope must be mentioned **electrical stimulation** of the heart, and **acupuncture** of that viscus.

One electrode is placed over the neck behind the sterno-mastoid at about the junction of its lower and middle thirds, while the other is wiped over the præcordium. This plan is, however, open to the objection that the electrical stimulation may produce inhibition and not excitation of the heart muscle. By stimulating the diaphragm to contraction, it may possibly aid respiration. **Acupuncture** of the ventricle with a gold needle is believed to act by exciting that viscus to contract through direct mechanical stimulation. The cases in which it has been done so far have not been encouraging. Massage of the heart by direct manipulation has been practised in a considerable number of cases, but without uniform success. In some instances, especially when heart failure has occurred during the performance of an abdominal section, the heart has been grasped from below and compressed rhythmically with a kneading motion of the fingers. In others the abdominal parietes have been divided and access obtained to the heart from below; while in certain cases the more formidable operation of resecting the ribs and a portion of the sternum over the pericardium has been undertaken. The heart movements were restored in all cases, and as long as artificial respiration was kept on the circulation was maintained. In most of the cases, however, respiration eventually failed and consciousness was never restored.

Syncope arising late in the course of an exhausting peration must be counteracted by the above methods of

treatment. Brandy may be rubbed over the tongue, lips, and gums, and, as soon as the patient has rallied sufficiently to be able to swallow, given in sips in hot strong beef tea. Sinapisms applied over the præcordium, epigastrium, and calves of the legs assist in producing reaction. The head should be kept low for some hours, and no attempt at sitting up allowed. Hot water, or better, hot saline (at 110° F.) injections into the bowel are of great value; they must be copious and may be repeated. Reaction is aided by hot water bottles applied to the feet and sides, and the flow of venous blood is promoted by firm rubbing of the limbs from the feet and hands towards the trunk. Inversion of the body, so that the feet are in the air, is often of signal service in extreme cases of cardiac weakness, *when there is no reason to believe that the right heart is engorged.* Brisk rubbing of the lips is often most useful.

During abdominal sections patients are especially prone to syncopal attacks under chloroform. These are due (1) to interference with the normal intra-abdominal pressure; this occasions draining into the abdominal veins, and hinders the passage of blood into the heart: (2) reflex interference with the heart arising from dragging upon the viscera, and especially from pulling upon the omenta and reflexions of the peritoneum. As soon as the parietes are sewn together again the patient's condition improves.

Epileptic and **epileptiform** seizures are very liable to occur as patients pass under the influence of chloroform. Beyond transitory weakening of respiration and fall of blood-pressure, no ill consequences arise as a rule. It is well in the case of known epileptics to place a gag in the mouth to avoid the tongue being bitten. The anæsthetic should be withheld during the fit.

After Effects of Chloroform.*

Bronchitis or **bronchial catarrh** occasionally follows the inhalation of chloroform, and must be treated on general principles. In all such cases it is difficult to eliminate contributory circumstances, *e.g.*, exposure, chilling of the body, etc. These conditions may follow the use of partly decomposed chloroform (*vide* infra).

Vomiting.—By attention to the directions given above (Chap. II.), vomiting is rendered less liable to occur. The following further directions, if duly carried out, will tend to the same end. If bilious plethoric persons have their bowels well cleared before taking chloroform they are less liable to sickness. The patient's head should be kept quite low; he should not be moved from the operating table for half an hour after coming to himself, and then the utmost care must be taken to prevent his being shaken, or his head raised.

Opium should not be given by the mouth; and unless there is obvious and urgent shock, brandy, ether, and sal volatile had better be withheld. Nor should food be taken, whether liquid or solid, for at least three hours after chloroform, and even subsequently abstinence from everything except hot water, which may be taken copiously if vomiting or nausea is troublesome, is best for six hours or so. Meat jelly, bread boiled in milk to which a pinch of bicarbonate of soda is added, or sponge cakes soaked in a light dry sherry, may be permitted after this time; tea, coffee, soaked toast, may be tried, but all indigestible or solid food should be denied.

In cases of persistent **vomiting** or **nausea** sips or draughts of very hot water will give most relief, especially if made slightly alkaline with bicarbonate of soda. Thirst

* For the medical treatment see also After-effects of Ether, Chapter IV.

is sometimes a painful after effect following very prolonged operations. This is especially so after abdominal sections. Copious enemata of hot water, frequently repeated, are of value. Lavage, performed at the close of the operation and before consciousness returns, is often most valuable, especially for persons who are prone to severe sickness. Drop doses of Tr. Nuc. Vom. or Tr. Ignatii Amaræ, well diluted with hot water, are certainly useful in less severe cases. Mackenrodt soaks a towel or handkerchief in vinegar (preferably cider vinegar), and arranges it so that the patient inhales the fumes. He finds it checks sickness and assists elimination of the chloroform. In obstinate vomiting sinapisms over the stomach, small doses of Eucaine Hydrochlor. (♏v. of 5%), oxalate of cerium, and codeia are valuable.

Dryness of the tongue, sometimes a troublesome complaint in the post-anæsthesia stage, is greatly relieved by Tinctur. Myrrhæ, Glycerin. Boracis, or by sucking a cloth soaked in Glycerin. ℥j., and Spir. vin. rect., and water in equal parts, ℥ij. (Kelly). Thirst and tongue dryness, especially frequent after operations upon abdominal viscera, are best treated by copious rectal injections of warm water given every three or four hours. It is stated, but I have no personal experience in the matter, that if patients are allowed to drink hot water up to two or three pints previous to the time the anæsthetic is inhaled, they are less sick and suffer from no nausea. The last glass of water is allowed half an hour before the anæsthetic. When morphine is given after chloroform has been inhaled, vomiting is certainly worse. It is altered in type, usually occurring after an interval of some twelve hours or so, and is commonly very severe.

Post-operation shock, in so far that it may in part be due to the anæsthetic, needs careful attention.

The patient lies cold, with clammy extremities, feeble pulse, and faint, sometimes irregular, respiration. Consciousness is slow in returning. The horizontal posture, application of warmth to all parts of the body, enteroclysis, rubbing brandy into the lips and buccal pouches, with constant friction to the legs and chest are the best means of restoring the patient. I have found hypodermic injections of strychnine and oxygen inhalations of the greatest value in these cases. In extreme conditions of shock transfusion of normal saline is called for, and will often restore an apparently hopeless case. Poncet has drawn attention to the dangers of the period of recovery from an anæsthetic. In more than one case patients whose respiration failed owing to malposition after they were placed in bed were recovered by his performing tracheotomy and ventilating the lung through the aperture so made. This plan succeeded when all the ordinary measures, *e.g.*, artificial respiration, etc., had been tried and failed. Poncet explains the mechanism by which death is averted in these cases by the following ingenious hypothesis. Under normal conditions the lungs can expand sufficiently to overcome the resistance caused by their elasticity and the obstruction in the air passages. Under an anæsthetic while inspiration remains fairly vigorous, the expirations grow rapidly more feeble. The muscular structures undergo paresis. At this point even a slight obstruction, fixation of the jaws, falling back of tongue, glottic spasm, or a collection of mucus, will prove too much for the individual's power to overcome, and asphyxia results. Tracheotomy, although but slightly increasing the patency of the air way, will, Poncet believes, by allowing *cold* air to enter, excite reflexly renewed and more vigorous respiratory movements.*

* See *Lyon Médicale*, Jan. 13 and June 16, 1895, pp. 35, 49, and 226.

After effects due to decomposition of chloroform during operations undertaken by gaslight are those arising from inhalation of irritant gases—phosgene gas, chlorine, hydrochloric acid fumes—and the treatment consists in assisting the elimination of the gases by opening windows, etc., and allaying the bronchial spasm by bland inhalations while the concomitant shock is treated on general principles. The danger is increased when the room is small and when the atmosphere is foggy. Several deaths have occurred resulting solely from phosgene gas poisoning.

Hysteria.—Fits of hysterics are sometimes excited in the neurotic by chloroformisation; no special treatment need be adopted. These attacks seldom last more than three or four hours, and should cause no alarm. In rare instances such seizures simulate acute mania, and the greatest care has to be exercised to avoid the patients doing themselves damage in the course of their frenzied struggles. Sedatives given by the rectum or hypodermically may be called for in really bad cases. They may occur in either sex.

Jaundice and general biliary derangement in some instances follow chloroform administration, especially after prolonged or repeated administrations. They should be treated upon general principles, and usually need give rise to no alarm.

Albuminuria and glycosuria may follow the use of chloroform. According to Baixer diabetics are injuriously affected by chloroform. In 24 or 48 hours they become restless, then drowsy, and finally pass into coma and die. These results are not by any means the rule, as I have repeatedly given chloroform to such persons without bad results. It is important, however, to limit the dose and curtail the time during which the inhalation is continued.

Upon the renal epithelium, chloroform excites a marked action. Legrain found albuminuria and cylindruria fairly common after chloroform inhalation, and more persistent although less in amount than after ether. Thomson and Kemp are led to believe, as a result of onconometric observations, that suppression never follows the inhalation of chloroform, and that the albuminuria is slight and transient. Wunderlich, Alber, and Rindskopf, however, agree with Legrain, and I think when pre-existing renal disease is present chloroform should be given very sparingly, to limit its irritant action on the kidneys. No special treatment is, as a rule, called for in chloroform nephritis.

Delayed chloroform poisoning.—An extremely curious after effect has been closely studied by Leonard Guthrie in this country, and by Brackett, Stone and Low, Baird, Favill and Bevan in America, and by many workers abroad. It has been known for a long time that a degeneration of the liver and other viscera takes place in dogs when they are compelled to inhale chloroform at frequent intervals. It is now recognised that similar pathological changes, affecting especially the liver, kidneys, heart, and muscular structures, may be brought about under certain unknown conditions in human beings, as a result of even one inhalation of chloroform. The symptoms usually appear between the 12th and 42nd hours after the inhalation. They are: repeated vomiting of foul watery fluid, which later is brown and resembles dregs of beef tea; restlessness, delirium, or excitement, alternating with an apathetic state which may deepen into coma. The breath has a strong acetone odour. The urine is scanty, albuminous, contains casts, while acetone or diacetic acid, sometimes both, are present. At length respiration and circulation fail, and death closes the scene. How far chloroform is responsible for the development of

this condition it is impossible to say. It is clear that the anæsthetic is not the sole factor, as out of the many thousands of persons who inhale chloroform, extremely few patients reveal the symptoms of acid intoxication with its pathological lesions. Nor can we trace any antecedent condition common to the patients. It is true that more instances of children so affected have been reported, but this may be explicable upon other grounds. The main points of practical importance seem to be that *limiting the amount of chloroform inhaled and restricting the strength of the vapour* are the surest safeguards against acid intoxication in chloroformed patients. The treatment of these cases has been carried out on general lines, and in some instances has proved successful. It is interesting, in this connexion, to notice the—

Effects of repeated inhalations.—Paul Bert made a careful study of the effects of daily administration of chloroform for a definite time. His researches were made upon dogs. After gradual failure of health, these animals died on the 32nd day with well-marked wasting of their organs and muscles, and fatty changes in the liver. Parasporo (*Il Policlinico*, Dec., 1897) has repeated these experiments and met with similar results. He further reports finding a similar fatty change in the tissues of a woman who died from an overdose of chloroform. According to J. Regnault and Dubois (quoted by Dastre), workers constantly exposed to the fumes of chloroform suffer from insomnia, neuralgic and rheumatic pains, with marked physical and mental depression.

Such conditions as ASTIGMATISM and INSANITY, although recorded as after effects of chloroform inhalation, are probably the results of general disturbance and are not due to the anæsthetic.

CHAPTER VI.

ETHYL CHLORIDE AND ITS MIXTURES —BROMIDE OF ETHYL AND LESS COMMONLY USED ANÆSTHETICS.

Chloride of ethyl (Chlorethyl), C_2H_5Cl, is employed both as a local and general anæsthetic.

Preparation.—Hydrochloric acid is passed into a boiling solution of chloride of zinc in ethyl alcohol in a flask with inverted condenser.

Physical and chemical properties.—Chloride of Ethyl is a colourless liquid with a pleasant ethereal odour resembling that of chloroform, S.G. ·920 at 32° F., boiling point 54·5° F. It burns with a smoky, green-edged flame, forming gaseous hydrochloric acid. When very concentrated it forms an explosive mixture with air. Very slightly soluble in alcohol and ether. No turbidity is produced by addition of silver nitrate solution to the alcoholic solution. It should contain no ether. There should be no appreciable diminution in volume when shaken with concentrated sulphuric acid, and no darkening of the acid should occur, indicating the absence of ether and other bodies. It should not redden litmus paper if allowed to be in contact with it for ten minutes. It should have no garlic odour (see also tests in new U.S. Pharm.). Evaporated from blotting paper no unpleasant odour should be detected, either during or after evaporation.

It is usually sold in glass tubes, which contain 60 c.c. By means of a spring stopper, the liquid can be sprayed into the inhaler, or upon lint, as the case may be. There

is little tendency to decomposition, but it is advisable to keep the tubes in the dark.

History.—Although chloride of ethyl has been adopted as a general anæsthetic only within the last few years, it was known and employed as early as 1848 by Heyfelder. Benjamin Ward Richardson included it in his "Synopsis of Anæsthetics," published in 1885, and gives 1849 as the date of its introduction by Nunneley, and 1852 as the year in which, conjointly with Snow, he demonstrated its value as an anæsthetic. The "Glasgow Committee" of the British Medical Association examined its action upon the lower animals and arrived at the conclusion, which they formulated in their Report published in 1880, that it was unsuitable for human beings, as it produced convulsions and respiratory failure. Its restoration to favour was due to the observations of Carisen and Miesing, who, when employing it as a local analgesic, found it induced general anæsthesia. Lotheisen employed it systematically as a general anæsthetic, and to his writings we owe much of our knowledge of this agent. The disrepute into which the drug had fallen was due to the impurity of the samples examined, and even now certain of the preparations give unsatisfactory results, so that care must be taken to obtain the anæsthetic from reliable makers. Some of the foreign manufacturers have attached fancy names to chloride of ethyl and its mixtures: it need hardly be pointed out that this procedure is undesirable and suggests that their preparations possess special powers; while it masks the character and properties of the drug employed, the use of which the advertisers are apt to vaunt as free from every sort of difficulty and danger.

Physiological action.—Profound narcosis, with complete anæsthesia, is rapidly produced when ethyl chloride is given and air is carefully excluded. No very complete

research into the action of this anæsthetic has been yet undertaken. Lebet, working with Dumont of Berne, found that intravenous injection produced in the case of rabbits marked circulatory depression. This agrees with the results at which Wood and Cerna arrived. Malherbe and Roubinovitch investigated the effects produced upon the arterial tension in man by means of Potain's sphygmomanometer, and found it was lessened in most cases. Koenig's results are in accord with their finding; and McCardie, who in this country has done much valuable pioneer work upon this subject, has satisfied himself that a fall of blood pressure takes place when ethyl chloride is given even for a short time. Seitz's sphygmographic results reveal a rise of arterial tension. Probably the truth lies between the extremes of opinion, and some observations of Koenig may explain the discrepancy. When air was completely excluded arterial tension rapidly fell, and death ensued from failure of respiration and circulation. In clinical work this exclusion of air is either avoided altogether or only practised for a very brief time, so that the arterial pressure does not undergo any material change.

Flushing, due to dilatation of peripheral vessels, is always associated with ethyl chloride inhalation, and may account in part for any fall in blood pressure which may take place. Respiration is profoundly affected, but, unless large doses of ethyl chloride are employed, is so secondarily to circulatory changes. Seitz, however, takes the reverse view, believing respiration to be affected first. Respiratory paralysis and failure of the heart's action result from the inhalation of large quantities of this drug, especially when the supply of air is much limited. Koenig asserts that in complete anæsthesia vagal inhibition is abolished. The nausea and vomiting which so frequently follow the use of this anæsthetic are probably due to reflex causes rather than, as in

the case of ether and chloroform, to a direct irritant action upon the mucous membrane of the stomach. Its action is very fugacious; patients rapidly lose and regain consciousness. Its elimination takes place mainly through the lungs; but, as Lebet has found slight albuminuria to occur, it is probable that when given for a prolonged period some passes through the renal filter. Its action as a local anæsthetic is due to its rapid evaporation causing ischæmia, and paresis of the terminals of the sensory nerves.

Danger and death rate.—It is extremely difficult to arrive at an accurate estimate of the safety of chloride of ethyl. Ware collected 11,207 cases and reported one death. Seitz and Konstanz place the death rate at 1 in 16,000. Several deaths have occurred recently in Great Britain, but this drug has now been used in a very large number of cases. Again, with regard to the fatalities the condition of the patient in some of the cases was very bad and should have been accepted as contra-indicative to the use of ethyl chloride. It is probable that chloride of ethyl is less safe than nitrous oxide, and must be placed between ether and chloroform in normal patients, but before ether when lung and kidney complications exist. Some authorities, however, believe ethyl chloride to be safer than nitrous oxide and other anæsthetics for administration to quite young children. The prudent will recognise, however, that it is not the wholly innocuous agent which some persons have asserted. In the hands of the experienced it is no doubt a fairly safe anæsthetic, but not one to be employed by the inexpert and incautious. McCardie's experience tends to confirm the view given above as to the safety of ethyl chloride, and he very wisely insists upon our recognising the limitations of its range of usefulness. My own experience, which is now extensive, leads me to believe that ethyl chloride is comparatively safe in suitable cases when properly given, but

may easily produce serious symptoms. I have never seen a death, but have had experience of two cases in which an alarming failure of respiration and circulation occurred. One patient was somewhat anæmic, but both were in average health, and there was nothing in the operations themselves or in the respective circumstances of these cases to have occasioned syncope. In each case complete anæsthesia was present, and a full dose of the anæsthetic was employed. The occurrence of serious complications, such as syncope, which in one case ended fatally, has been recorded by Ware, Lothiesen, and others. Respiratory failure is probably the most common accident, certainly so in the case of children, but danger may arise from the side of the circulation and is then more serious.

Preparation of the patient.—This should be the same as in the case of chloroform or ether. It is advisable that food be abstained from for four hours, and the last meal taken should be light and digestible.

Posture.—Unless the patient is very asthenic, any position, sitting or reclining, may be adopted. The clothing must be loose, and everything which interferes with breathing removed.

Administration.—Many methods have been suggested, but for routine work there is little doubt that chloride of ethyl is best administered from a closed inhaler, partial or complete exclusion of air being practised.

The inhalers depicted and described below are simple and efficient. The first, which has been modified by Mr. Beresford Kingsford from Dr. Boyle's wide-bore inhaler (with lint lining the inside of the mask), ensures that the breathing shall be free and unrestricted. The "Ideal" is the suggestion of Mr. Vernon Knowles, and is supplied with his reversible rubber bag which enables the anæsthetist to ensure cleanliness in his work. The "Simplex"

is from the design of Dr. Luke, of Edinburgh, and is excellent.

Many inhalers, too numerous for mention and each possessing some merit, are to be obtained. Of these several are simple adaptations of Clover's Regulating Ether inhaler. When no special inhaler is at hand, a ready substitute can be made by having an opening bored into the metal knee-shaped mount, which carries the rubber bag of the "Clover," and connects it with the ether chamber. The bag is then fitted directly with the face-piece, the ether chamber being discarded unless the sequence of ethyl chloride and ether is to be employed. The opening made in the knee-piece serves for spraying in the chloride of ethyl; it is made just large enough to take easily the nozzle of the stopcock on the ethyl chloride tube. It is quite possible to make an inhaler from lint or a towel folded into a cup-shape; although, as a rule, the device is not satisfactory, it serves its purpose very well in the case of very young children, and in that of extremely nervous patients, who dread the application of any apparatus.

Chloride of ethyl may be given by itself: (1) in sequence with nitrous oxide; (2) in sequence with ether; (3) before chloroform; (4) in various mixtures. These are: various admixtures of methyl and ethyl chlorides; mixtures containing these with bromide of ethyl added; in combination with chloroform.

It is proposed to consider these varieties in the use of this anæsthetic, although the administration of the drug given in the pure state will receive most attention, as the principles involved in this control, in the main, the methods adopted with the sequences and mixtures.

Indications and contra-indications for its use.—Dr. Flora Murray * has used chloride of ethyl

* *Lancet*, November 25, 1905.

as a routine anæsthetic for children from 5 days old and upwards with strikingly good results. I have employed it for the aged* as well as the very young, and that without difficulty or danger. Dr. McCardie considers that conditions causing blocking or stenosis of the air passages are contra-indications, and with this I agree. Among diseased subjects my experience is that, while no chronic or acute disease, as such, is a contra-indication, yet lung diseases involving marked respiratory difficulty, especially when associated with bronchorrhœa, are liable to cause dangerous developments when chloride of ethyl is given. In a case of aortic aneurism in which I administered this anæsthetic, the narcosis was free from any unfavourable symptoms.

From the operative point of view, when complete muscular relaxation is required, my experience has not been in favour of chloride of ethyl, as it does not appear to relax muscles so well as ether or chloroform. It must, however, be said that Dr. McCardie, whose experience is extensive, does not agree with this view, and contends that, with care and an adequate dose of the drug, muscular relaxation can be usually obtained. A rather remarkable fact, to which my attention was called by Mr. Rowell, is that, when in alcoholics under chloroform the muscles are rigidly fixed, they may be caused to relax immediately by spraying a few c.c. of chloride of ethyl on the mask. Similar results follow when ethyl chloride is used during ether narcosis (Kingsford). I have no experience of chloride of ethyl in midwifery practice, but it has been employed and, it is stated, with success. Alcoholic persons are not good subjects for chloride of ethyl. They are apt to become extremely violent and often the anæsthesia in their case is very short. In some instances it is extremely difficult to produce a satis-

* In the case of those advanced in years great care is needful, and the recumbent posture a *sine quâ non*.

factory and quiet anæsthesia in such persons, even when using a large dose, *i.e.* 10 c.c. The patients are unaware of their proceedings, but their movements are too violent for the operations to be successfully performed. Smokers suffering from pharyngeal catarrh do not always take this anæsthetic well; they are liable to cough, strain, and struggle for air. When the heart's action is feeble and

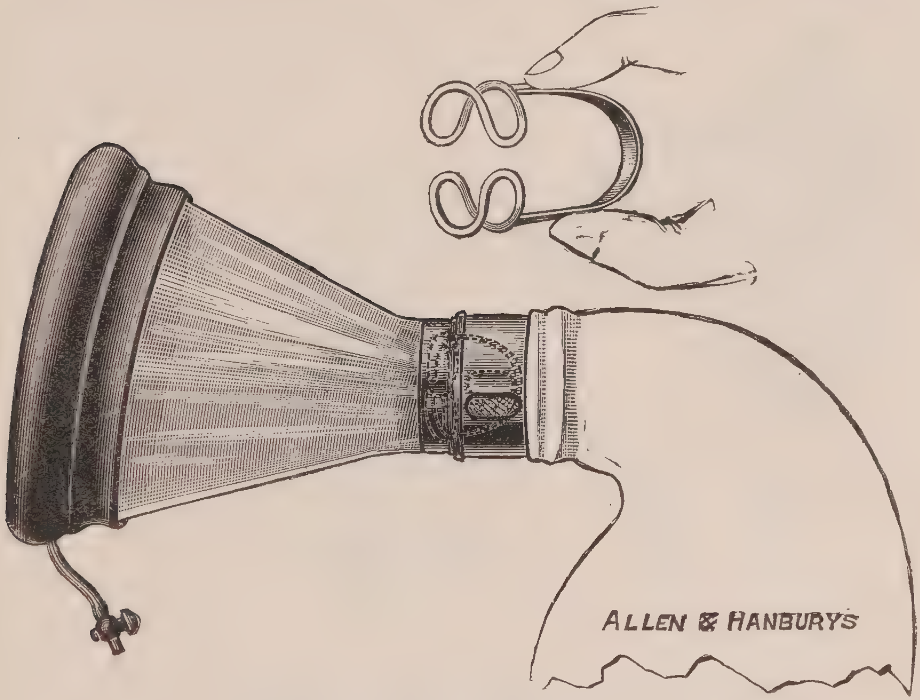


Fig. 49. Wide-Bored Chloride o Ethyl Inhaler (Kingsford).

there is probability that this is due to fatty degeneration, chloride of ethyl is contra-indicated.

Inhalers.

I. Wide-bored Inhaler.—In this excellent and simple inhaler, as modified by Mr. Beresford Kingsford, there is no lint in the face-piece, so that the patient's face can be seen throughout the administration. The

neck of the bag fits over that of the face-piece, and can be freely rotated about it. Corresponding openings are made in the inner and outer necks, and when these coincide the anæsthetic can be sprayed through them into the bag. Within the neck of the face-piece a piece of lint is fixed (opposite the aperture) by a clip, so as to form a pocket which is open towards the bag, just as an aortic valve forms a pocket open towards the aorta. The lint minimises reflux of the spray into the face-piece and economises the anæsthetic. When a gag is used, the inhaler can be applied *uncharged* the moment the gag is adjusted, and then can be charged during a convenient expiration. After a breath or two the air-way is closed by slightly rotating the neck of the bag.

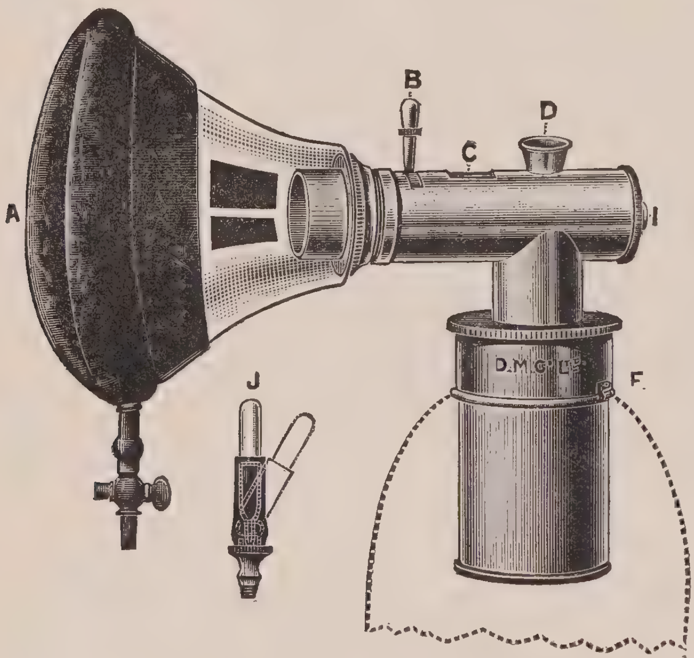


Fig. 50. "Ideal Inhaler"* (Vernon Knowles). A, mask with pneumatic rim; B, lever controlling air inlet; C, air inlet; D, supply aperture fitted with worm to fix capsule crusher, which is shown at J; F, connexion to rubber bag.

II. The "Ideal" is constructed to enable the administrator to give ethyl chloride freely diluted with air. I have little doubt, from my experience with this inhaler, that the principle is a correct one. Patients are less

* Made by the Dental Manufacturing Company.

as can be performed when one, or at the most two, inhalations are allowed. The patient should be seated comfortably, and his legs so disposed that if, as often happens, he forcibly straightens them he cannot prize himself out of the chair or break its back. The head should be slightly extended, and breathing absolutely unrestricted. A dental gag is placed securely in position and the face-piece carefully applied with the supply aperture open. There must be most accurate coadaptation, so that *no air enters under the inflated rim of the mask.* A few breaths having been taken, 3 c.c., in the case of an adult, are then sprayed through the aperture into the bag during a forcible expiration, and at its end. The aperture is then closed and the patient encouraged to inspire freely. If he holds his breath, as may happen with nervous patients, the chin should be sharply jerked upwards, which induces an inspiration. After fifteen or twenty seconds, when the breathing has become fuller and more rapid, the aperture is again opened during an expiration, and 2 c.c. more of ethyl chloride are sprayed in. If a prolonged anæsthesia is desired and the patient is vigorous and full-blooded, 3 c.c., or even 4 c.c., may be given rather than 2 c.c. The plan of dividing the dose, which I have adopted and described, is based upon the following observation. Patients when they commence breathing chloride of ethyl not rarely breathe feebly, and do not inspire the full dose from the bag. As, however, they become partly narcotised the respirations grow more vigorous, and the second dose of chloride of ethyl, which is then sprayed into the bag, is inspired freely, and this ensures a good and prolonged anæsthesia. In thirty to sixty seconds from the commencement of inhalation, the breathing will become loudly and musically stertorous, and the patient is then completely anæsthetic. He remains in this state for a minute or more. The longest anæsthesia I have

met with lasted for five minutes (5 c.c. having been given); a duration of two or three minutes is not uncommon.

The stertor deepens; in most cases the eyeballs will be fixed—being usually rotated downwards—and the pupils dilated; the anæsthesia is then complete. The degree of insensibility is very profound, yet, if the anæsthetic is withdrawn as soon as well-marked stertor is present, it deepens for a few seconds afterwards. This deepening of narcosis after the mask is withdrawn is very considerable in children of any age under seven years. It will often happen that if the mask is withdrawn while the child is still crying, and the operation (a short one) is commenced, insensibility becomes more complete. There is no corneal reflex, the crying subsides, and the reflex will only return after an operation has been performed without evoking a struggle or sign of consciousness.

If, in such young children, the anæsthetist waits for cessation of crying, or is induced to give more anæsthetic to effect deeper narcosis, failure or danger from overdose will certainly be incurred.

That the action of chloride of ethyl is very fugacious is shown by the rapidity of recovery. For a few seconds after anæsthesia ceases the patient is dazed and has little control of himself or his movements, but this is followed by restoration to complete consciousness. In these respects chloride of ethyl resembles nitrous oxide and contrasts with chloroform or ether narcosis. As soon as stertor appears, the mask should be removed and the operation commenced, for if the anæsthetist delays removal of the mask with the view of obtaining a longer anæsthesia, he will find, to his chagrin, that during the delay the chloride of ethyl has partly or wholly become dissipated and consciousness is returning.*

* It is often very difficult to avoid slight leakage between the mask and the face of the patient, and even if this is very slight, it will be sufficient to dissipate the chloride of ethyl.

If, after the inhalation has lasted 60 seconds, there is no stertor, more anæsthetic must be given, as the narcotic effect is never delayed beyond this point. It is important to remember that the narcosis, while it lasts, is very deep and the reflexes are in abeyance, and thus operations on the upper air passages involving hæmorrhage may prove dangerous (or even fatal), unless care is taken to direct the blood out of the mouth.

(2) Prolonged operations. Although the consensus of opinion is not in favour of the use of chloride of ethyl for longer operations, except sometimes in the case of young children, yet it may be well to indicate the technique of its management for operations of from five to twenty minutes' duration.

The patient must be carefully prepared, just as in the case of ether or chloroform. The induction is conducted as has been described already, and when anæsthesia is obtained the mask is either removed or the inspiry valve opened, the patient being permitted to ventilate the lungs with air. As soon as stertor disappears and the eyeballs commence to move, 3 c.c. or 4 c.c. are sprayed into the bag. This is repeated as often as may be necessary to maintain anæsthesia.

It is seldom advisable to give more than 5 c.c. at one time, although in the case of alcoholics and vigorous men it may be necessary to use 3 c.c. or even 5 c.c. after the initial dose before complete anæsthesia is obtained. As a rule, 3 c.c. are sufficient for children and 5 c.c. for adults. It is, however, important to ensure that this dose really enters the patient's lungs. To this end the mask must fit accurately, the patient must be encouraged to breathe freely during the induction, and the respirations must be sufficiently vigorous to nearly empty and refill the bag. Children, especially young and feeble children, cannot do this, and so when the anæsthetic is not sprayed upon lint

or a sponge near to their mouths they do not get enough of it. This difficulty is met by the lint in the inhalers of Dr. Boyle and Mr. Knowles, and can easily be overcome in other inhalers by placing a coil of lint in the summit of the face-piece.

Chloride of ethyl in operations upon children.—Dr. Flora Murray* regards this anæsthetic as preferable to chloroform for children. A simple bag with celluloid face-piece, fitted with a wire holder to keep a piece of lint in position and an aperture in the connecting shaft, is all that is required. A dose of 3 c.c. is suitable for infants of a few months old and 5 c.c. for children a few years old. The mask is held near, but not touching, the face for the first breath or two. The chloride of ethyl is sprayed on to the lint; it is then applied closely. The child should **not** be held more than is necessary to prevent his hands from clutching the inhaler. Stertor appears in a few seconds, the eyeballs are fixed, and deviation is commonly seen, the pupils are variable, the respirations rather rapid and deep. As recovery comes on these grow slower and more shallow. Repeated doses may be given, respiration being closely watched. If it begins to fail, the chest should at once be compressed and the anæsthetic withheld until breathing is fully restored. The after effects are usually slight.

Methods of giving Chloride of Ethyl in Combination

(1) **With nitrous oxide.**—This combination has been suggested, and many regard it as possessing special advantages.†

* *Lancet*, November 25, 1905, p. 1542.

† Dr. Hewitt introduced this method at the Annual General Meeting of the British Dental Association, June 1903. See *Brit. Dental Assoc. Journ.* for 1903, p. 615.

The chloride of ethyl is sprayed into a tube or bottle, which is attached by an india-rubber tube to a tap in the distal end of a Catlin's gas-bag after this latter has been partly filled with nitrous oxide. Experience is necessary to gauge the quantity of gas requisite for each patient. The patient breathes the gas, and after a few respirations the expiry valve is closed, and rebreathing takes place for a few seconds; then the stopcock is opened and the chloride of ethyl is allowed to evaporate, or, if necessary, is tilted into the gas-bag. My experience of the method has not convinced me of its superiority over simpler procedures, except when it is desirable to give a patient nitrous oxide because he is already familiar with it, and yet obtain the more lasting and profound anæsthesia of chloride of ethyl.

(2) **With ether.**—It may be used instead of nitrous oxide as a means of introducing ether. The induction is as described above, and ether is given as soon as stertor is well marked, at first in moderate strength, but rapidly increasing it to "full ether." Cyanosis may be produced if the ether is presented too soon, and is always a warning that a breath of air must be given.

(3) **With chloroform.**—As regards giving chloroform immediately after chloride of ethyl, I think it is best in all cases to avoid it and let the chloroform follow the ether-after-chloride-of-ethyl sequence. It is justifiable, no doubt, to obtain deep anæsthesia by chloride of ethyl and then, during an operation upon the naso-pharynx or neighbouring regions, pump in chloroform vapour by means of a Junker's inhaler and mouth or nasal tube. Even this, I think, is more liable to lead into difficulty or danger than the plan advocated above.

Difficulties and dangers.—The dangers are **interference** with **circulation** and **respiration.** Very **young children** occasionally stop breathing during the period of induction. This, Dr. Flora Murray thinks, is the result of over-stimulation of the respiratory centre. The explanation is not, perhaps, quite satisfactory, as blood pressure in such cases is distinctly low; but from whatever cause it arises, the complication, though an alarming one, fortunately seldom proves serious. The removal of the chloride of ethyl, lowering the head, and compression of the chest rapidly re-start respiration.

In adults embarrassment to respiration, cyanosis, faintness or syncope may occur. Such accidents, although rare, may arise through giving a large dose, such as 8 c.c. or 10 c.c. ; lack of attention to the correct posture for carrying on unimpeded breathing ; collateral circumstances which interfere with respiration, such as falling or pressing back of the tongue *e.g.* during the extraction of lower teeth. Blood passing backwards to the larynx is again a cause of such dangers. Cyanosis or pallor, rapid, shallow, and laboured breathing, should be watched for and at once recognised as a warning of danger. The anæsthetic should be withdrawn, and if a gag has been placed in the mouth it should be removed while the jaw is pushed forward; and if need be, the tongue seized and pulled forward and the head lowered. In extreme cases, when there is actually cessation of respiration and of circulation, the patient should be placed in the horizontal position and artificial respiration performed, the tongue being held forward and the upper air-passages cleared of blood and secretions. Young children should be placed on their right side and the chest rapidly compressed. If these measures fail, laryngotomy must be performed.

The fatalities which have occurred have been due to the failure of circulation and respiration.*

After effects.—Vomiting and **nausea** are more frequent after chloride of ethyl than after nitrous oxide inhalation. This is partly accounted for by the profoundness of the narcosis. The patient is allowed to swallow blood and mucus. If care be taken that the head is so placed that this does not occur and sponging be carried out with more thoroughness than is usual, it will be found that vomiting is by no means a necessary sequela.

In dental hospital practice I found 9·6 per cent. of patients vomited, and to these must be added 4·8 per cent. of cases in which there was some nausea or retching. The cases examined were not prepared for the anæsthetic; some had taken a meal, several had taken alcohol just before entering the hospital. It must be pointed out further that, in these cases, extensive dental operations were carried out, involving the removal of several teeth, and the blood effused was swallowed during the progress of the extractions before the patient was aroused, so that the figures given are probably the most unfavourable which could be cited.

There does not appear to be so much headache or persistent vomiting as after ether or chloroform; nor is the after bleeding increased when chloride of ethyl is inhaled. It has been stated that the immediate hæmorrhage is increased, but this is not always the case.

* Cf. *Transactions of So. of Anæsthetists*, vol. vii. pp. 91, 99, 103, 119, 129. See also below Chapter X., "Accidents of Anæsthesia." A recent death under ethyl chloride may be mentioned here. The patient, aged 67, was given 5 c.c. for a dental operation, and died before its completion. It was discovered at the necropsy that he had a "fatty heart." Unless the patient is hale and has no enfeeblement of circulation and no respiratory embarrassment, ethyl chloride should not be given to the aged, and certainly only in the recumbent posture.

Mixtures containing Chloride of Ethyl.

Of these the best known are somnoform (sometimes spelt sœmnoform or sœmnoforme), narcotile, kelene, and anæstile. Kelene, narcotile, and anæstile are either chloride of ethyl pure and simple, or are mixtures of it with chloride of methyl.

Somnoform * is composed of chloride of methyl 35 parts, chloride of ethyl 60 parts, and bromide of ethyl 5 parts. It was suggested that the extremely volatile chloride of methyl (B.P.—22° C.) hastened anæsthesia, the chloride of ethyl gave the character to the mixture, while bromide of ethyl, the least volatile, served to prolong and deepen the narcosis. The mixture is extremely volatile, and if exposed to light and air undergoes decomposition, owing to the liberation of free bromine. Even when fresh it has a rather unpleasant odour.

Sydney W. Cole † has undertaken, under strictly scientific control conditions, a research into the physiological action of this mixture, and finds its behaviour is in the main that of bromide of ethyl. Dr. Swan ‡ has also conducted a limited research, while the originator of the mixture § has published his view of the action of somnoform.

Mr. Cole found somnoform increased the range and rate of contraction and the tone of the diaphragm; large

* Introduced by Dr. G. Rolland in 1901 at the meeting at Ajaccio of the Congress of French Associations for the Advancement of Sciences (Odontological Section), and by him and Dr. Field Robinson at the Annual General Meeting of the British Dental Association at Shrewsbury, 1902. See *Brit. Dent. Assoc. Journ.*, 1902, p. 321.

† Proceedings of the Physiological Society, May 16, 1903, *Journal of Physiology*, vol. xxix. The reader should also consult the paper by Dr. Adolf Haslebacher, "Experimentelle Beobachtungen über die Nachwirkungen bei der Bromæthyl- und Chloræthylnarkose," Bern, 1901.

‡ *Proceedings of Society of Anæsthetists*, vol. vi., 1903, p. 49.

§ *Op. cit.*

doses caused death by setting up powerful tonic contraction of the diaphragm with arrest of respiration, while the heart still beat strongly. This occurred when the vagi were divided, and therefore was due to action on the respiratory centre. An initial rise in blood pressure, with acceleration of the heart beat, was followed when the dose was increased by fall of pressure. The strength of the heart's contraction was lessened. No effect on the vaso-motor system was noticed. Animals usually struggled, even after complete loss of corneal reflex, and regular rhythmic movements of the muscles of the limbs, tail, and jaws persisted; while muscular relaxation was seldom complete, even with large and dangerous doses. The pupil at first dilated, and subsequently contracted. Dr. Swan has examined the blood of patients before and after taking somnoform, and found no change in the amount of hæmoglobin, or in the number of leucocytes.

Administration.—The character of the anæsthesia varies with the strength of the somnoform vapour employed. If much air is allowed to enter with the vapour, analgesia and violent movements are produced, but no true anæsthesia.

Given without air, some feeling of suffocation is experienced, but the average period of induction is very short, viz. 20 to 30 seconds, while a tranquil and profound anæsthesia follows, which usually lasts for 60 to 100 seconds. It is claimed that a five minutes' anæsthesia can be obtained with 5 c.c., but this must be very exceptional. The length of the period of unconsciousness depends upon the vigour of the initial respirations. It is well to bear in mind when using somnoform that the induction period varies within wide limits. Thus, children under seven, who cry or breathe deeply, may become anæsthetised in 10 or 12 seconds, while vigorous or alcoholic or neurotic

adults may require a full minute before unconsciousness is produced. If more air is admitted, as when a patient breathes and rebreathes air into a small bag into which somnoform has been sprayed, the induction takes 40 to 50 seconds.

The methods of administration are similar to those described for chloride of ethyl. Thus, it can be sprayed upon the lint fixed inside the face-piece of Mr. Vernon Knowles's inhaler, additional doses being given, if necessary, by spraying through the opening into the bag, or it can be sprayed directly into the bag in this or other inhalers. The dose is somewhat less than that of simple ethyl chloride, being 2 c.c. to 3 c.c. for children, 3 c.c. to 5 c.c. for adults, according to their physique and vital capacity.

Phenomena of narcosis.—The face flushes as with chloride of ethyl, the pink-red deepens almost to cyanosis if large doses are given, the respiration is quickened, but grows weaker and less full, and faint stertor is usually heard; the eyes become suffused and the eyeballs fixed in a position of deviation downwards and slightly inwards; more rarely the deviation is upwards; the pupils at first dilate, but later on, according to some observers, they become smaller. Mr. Kingsford, who has studied the changes of the pupil in 1,700 cases of somnoform anæsthesia, informs me he has never seen the pupil undergo contraction while the ocular globes remained fixed. After moderate doses the pulse is quickened, but is usually little altered in volume. If very full doses are administered, duskiness, distinct feebleness of breathing, with quick, collapsing pulse result. Anæsthesia is present when the breathing is stertorous, and the mask should be removed—and in the case of children even if the conjunctival reflex is present, and the ocular globes are still moving. The depth of narcosis is increased for some seconds after the patient ceases to

inhale; indeed in very young children the narcosis may continue to deepen for half a minute or even more, and this must be allowed for in determining the right moment for withdrawal of the anæsthetic.

After effects.—Much difference in the statements of those who have had large experience with somnoform exists as to the after effects produced by it. I think, however, that there is little doubt that nausea, vomiting, and severe headache are common sequelæ. The patients are commonly dazed for some minutes after the inhalation, more so than after chloride of ethyl.

Difficulties and dangers.—Unless air is almost completely excluded, no anæsthesia will result. A mistake which results in failure is often made in keeping the mask too long on the face. If the signs of anæsthesia are not developed in 30 or 40 seconds, too much air has been allowed, or too small a dose has been given. When food has been taken within a short time of the administration of the anæsthetic, pallor is likely to occur, followed by vomiting into the mask. Several cases have been reported in which severe collapse occurred, lasting for some hours and causing alarm. Mr. W. Cross Foster * mentions two cases in which marked general rigidity, opisthotonus, and spasm of the jaw muscles developed. And Dr. Swan † cites two cases of collapse, one in his own and one in the practice of Dr. Rolland. In both the patients had had anæsthesia prolonged by somnoform for twenty minutes. Excitement and struggling are occasionally met with. As Dr. Kirkpatrick ‡ indicates, micturition is common if the bladder is not emptied before the administration, so this precaution should not be omitted. I have met with cases of excitement, but none of serious danger. Fatalities have

* *Proc. Soc. Anæsth.*, vol. vi. p. 45. † *ibid.*

‡ *Med. Press and Circ.*, April 22, 1903.

occurred, however, during the use of somnoform ; and when we bear in mind that Cole's experiments show conclusively that the physiological actions of somnoform and bromide of ethyl are almost identical, it follows that the dangers of somnoform must be almost the same as those of bromide of ethyl ; and with these we must reckon. Somnoform readily decomposes ; if any free bromide is present, the colour becomes yellow and the anæsthetic is unfit for inhalation. As a rule, the last portion in the bottle gives unsatisfactory results, especially if the bottle has been open for a day or so, and should not be used.

All who have used somnoform are struck with its obvious merits, but there has been an unwise reticence with regard to its known dangers. It is, therefore, by way of warning that I have maintained this mixture should not be employed by those who are not fully aware of ALL its properties, and able to recognise and combat perilous complications as they arise. Comparing it with chloride of ethyl, one is justified by the facts in saying that the latter agent is safer and quite as efficient, even if it is less rapid in inducing and less satisfactory in maintaining anæsthesia than is somnoform.

Ethyloform is a mixture of bromide of ethyl 10 per cent. ; chloride of ethyl 45 per cent. ; and chloride of methyl 45 per cent. As far as I know, its physiological action as yet has not been worked out. Judging by the analogy of somnoform, however, it seems probable that the 10 per cent. of bromide of ethyl which it contains would dominate and give the mixture an identical action with this agent. It is exhibited in the same way as somnoform.

Narcotile,* kelene, anestile, and other anæsthetics which are sold under similar names are too uncertain in

* Dr. Tom Eastham, *Lancet*, April 18, 1903, p. 1091, gives his experience of narcotile, which he terms "bichloride of methyl ethylene."

composition to require more than a passing notice. These agents, although disguised by meaningless names, are really either chloride of ethyl or consist of mixtures of it and chloride of methyl. Anestile probably contains a little ether as well as the chlorides of ethyl and methyl. The mode of administering them needs no special mention, as it is that already described under the heads of "chloride of ethyl" and "somnoform." It may be pointed out that the importance of securing pure drugs is paramount in the case of anæsthetics, and it is therefore wise to obtain them from the best makers, and work with agents the composition of which is known and can be readily tested for purity and stability.

Recently the presence of chloride of ethyl in certain brands of chloroform has been noticed, and it is claimed that the more volatile agent renders the inhalation more rapid and more generally satisfactory. However, unless chloride of ethyl is added in appreciable quantity—such, for example, as 3 per cent. or more—it is at least difficult to understand how its presence in chloroform can exert any marked action during the induction period.* We do not possess as yet sufficient evidence to come to any satisfactory conclusion as to the advantage of adding chloride of ethyl to chloroform. It is certain, however, that the mixture is more volatile than chloroform, and that during evaporation the composition of the mixture remains practically unaltered.

Uses of Ethyl Chloride and its Mixtures.

For brief operations such as those of dentistry, the removal of tonsils and post-nasal adenoid growths, opening of abscesses, and generally for occasions when nitrous oxide

* See Dr. Wade's paper in *Trans. Soc. Anæsth.*, vol. vii. p. 84.

is commonly employed, chloride of ethyl is valuable. For short operations upon infants and children under six years of age it is the best anæsthetic we possess, being more readily taken than ether when that agent is given by itself, easier to manage than nitrous oxide for very young children, and safer than chloroform. It is also a valuable means of introducing ether narcosis, and especially so in the case of nervous persons. Its use has been extolled in the operations of ophthalmology, and for those of the rhinologist, aurist, and laryngologist, when the time required by the surgeon is not more than two or three minutes. For more prolonged operations upon the mouth and upper air-passages, chloride of ethyl as usually administered is inconvenient, since the surgeon is obliged to interrupt his work while the mask is reimposed and more anæsthetic is given. Dr. Barton* has devised a useful apparatus by means of which the anæsthetist is enabled to give the vapour of chloride of ethyl continuously. For this purpose the vapour is carried by a tube either through the nostril or to a delivery-tube attached to a gag. The supply of vapour is maintained by warming, by means of hot water, a specially constructed cylinder holding 250 grammes, and is controlled by taps, so that the narcosis can be kept at the desired depth for as long as may be necessary.

A few words may be said as to the comparative merits of nitrous oxide gas and chloride of ethyl, since these anæsthetics are used in similar cases.

Chloride of ethyl is more portable, it does not produce cyanosis unless given for too long a time and without air, and it ensures a deep and quiet period of anæsthesia which is considerably longer than that obtained by the inhalation of nitrous oxide. On the other hand, it is probably less

* "A Guide to the Administration of Ethyl Chloride," p. 21, Lewis & Co., London.

FIG. 53. Dr. Barton's apparatus for administering chloride of ethyl for prolonged operations on the mouth or nose. Induction about to commence.

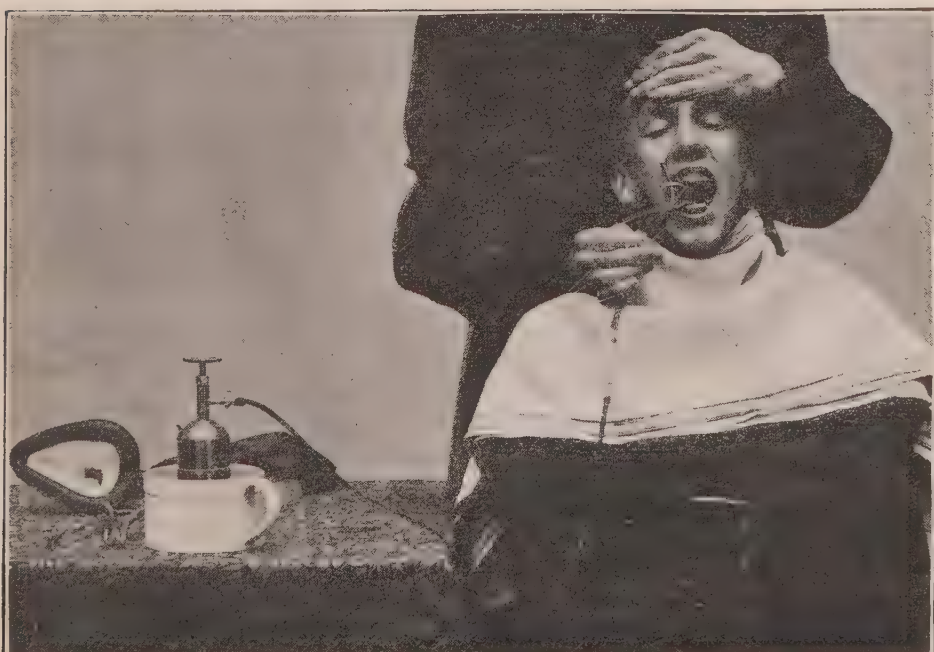


FIG. 54. Anæsthesia being maintained by means of the tube.

safe, and more liable to produce after-nausea and vomiting. In dental surgery I think chloride of ethyl should not replace nitrous oxide as a routine anæsthetic, but should be used in the place of that gas when followed by ether, for cases of numerous or difficult extractions, such as those of the lower wisdom-teeth. For cases of multiple extractions in the upper jaw in persons with a short upper lip who are less easily kept anæsthetic by a continuous gas method, chloride of ethyl is useful. For the removal of tonsils and growths in children, more especially in hospital practice, chloride of ethyl is better than nitrous oxide; it is, indeed, considered by some as almost an ideal anæsthetic in these cases.

Ethyl chloride may be strongly recommended for nasal operations, such as removal of spurs and portions of turbinate bones. It causes less congestion, and affords a quieter anæsthesia than nitrous oxide followed by ether (of at least equal length). It is safer than chloroform or its mixtures when given to patients in the sitting or semi-recumbent posture. It may be used safely before cauterising the turbinate bodies.

Patients who are inclined to become cyanosed when inhaling nitrous oxide, and those who "come round" very quickly, and those who are restless and excited under that agent, usually respond well to ethyl chloride, and by its use a satisfactory anæsthesia can be obtained.

Bromide of ethyl (hydrobromic ether), C_2H_5Br, sp. gr. 1·4733, boils at 38·3° C., and remains unchanged at 0° C., thus differing from the toxic body, ethylene bromide, which crystallises at zero. It is a colourless translucent liquid, with a neutral reaction, ethereal smell, and a pungent sweet taste with a somewhat burning after-flavour. It is ignited with difficulty, and burns with a green smokeless flame, emitting an odour of hydrobromic

acid (Löwig). It is insoluble in water, but freely soluble in ether or alcohol. It rapidly undergoes decomposition in the presence of air or light, with the liberation of free bromine, and becomes irrespirable. This impurity gives it a yellow colour, a circumstance which should warn against its use when at all tinted. Serullas discovered this substance in 1827, but to Nunnely of Leeds we are indebted for its recognition as an anæsthetic (1849).*

Physiological action.—Rabuteau, in 1876, carefully investigated the subject.† In human beings bromide of ethyl produces unconsciousness and anæsthesia in one minute, and complete muscular relaxation in two or three minutes. Schneider speaks of two periods: in the initial one sensibility is lessened without loss of consciousness or interference with respiration and circulation; in the second there is complete loss of consciousness and occasionally convulsive seizures. Larger doses produce profound narcosis, cyanosis, muscular relaxation, loss of pupillary reflex, and gradual failure of respiration and circulation. The heart beats for an appreciable time after breathing has ceased. Elimination takes place by the lungs. No suffocation or laryngeal irritation appears to exist, although there is much congestion of the head and neck with lacrimation, and an increased secretion of mucus which may give trouble.

When ordinary doses are given to produce anæsthesia, the following phenomena occur: The breathing is quickened,

* The late Sir B. W. Richardson wrote (*Asclepiad*, 1885) favourably of its claims, and urged that pure samples were free from the dangers which arise with the commercial bromide. The bibliography of bromethyl has become very large; important papers have been written by Hartmann and Bourbon (*Rev. de Chirurg.*, No. 9, 1893, p. 701), Dastre ("Des anesthétiques," p. 189, Paris, 1890), Lewis (*Medical Review*, New York, March, 1880, p. 342), Turnbull of Philadelphia, Chisholm and Silk (*Practitioner*, May, 1891), among many others. A useful list of authorities will also be found in the valuable chapter on bromethyl in Terrier and Péraire's book ("Petit Manuel d'Anesthésie Chirurgicale," Paris, 1894, p. 154), to which the reader is referred for greater detail.

† *Comptes rendus de la Soc. de Biol.*, t. xxxiii. p. 1294.

the pulse accelerated, and the heart's action somewhat weakened. The pupils dilate. The return to consciousness after withdrawal of this ether is very rapid. Vomiting is said to occur frequently during the administration, and even to continue for some hours after. Blood-pressure, according to H. C. Wood, is slightly reduced by small, and very considerably by large, doses of this agent.

Deaths from bromide of ethyl are due, according to Wolff and Lee, to cardiac failure; but these statements are denied by some observers. Ott, on the other hand, believes ethyl bromide kills by direct action upon the respiratory centre, and does so whether it is injected intravenously or is inhaled. The heart-failure, he thinks, is secondary to the interference with respiration. According to Ginsburg, this fall of blood-pressure is due to paralysis of the vasomotor centres, the vagus centres being unaffected. The action of this agent upon the heart is probably similar to that of chloroform (H. C. Wood). Tcherbacheff corroborates Wood's results, and asserts that death is caused by cardiac paralysis and pulmonary œdema. Cole was unable to detect any effect on the vasomotor system; he agrees with Wood and others in believing that respiration is affected by action upon the respiratory centre.

Method of administration.—In giving bromide of ethyl, air is usually entirely excluded. Turnbull, however, allows some air at the commencement of the inhalation. An Ormsby's or an Allis's inhaler apparatus answers very well. When an Ormsby's inhaler is used, a drachm or a drachm and a half are poured upon the sponge, air being excluded until consciousness is lost (Silk). Anæsthesia is recognised by snoring and loss of conjunctival reflex. This is usually reached in half a minute to a minute, and at this point the inhalation must be stopped. Although it is asserted by some observers that

there is little struggling, violent movements certainly take place in some instances. Owing to the great rapidity with which consciousness returns (1 to 3 minutes), careful attention is needed on the part of an anæsthetist to maintain narcosis. The respiration and pulse require watching throughout the administration. No prolonged operation should be attempted under ethyl bromide; even when it is given intermittently authorities agree that the inhalation should not be continued beyond forty minutes. It is, however, best adapted for quite short operations.

Hartmann and Bourbon adopt the following plan: 10 to 15 grammes (2-3 drachms) are placed on a compress, and as soon as the patient grows used to the odour the compress is placed tightly over the mouth and nose. If any struggling occurs, the patient is held in the recumbent posture for a few seconds, when he becomes quiet. Anæsthesia supervenes after a dozen breaths, *i.e.* in about 30 or 40 seconds. Inhalation must now cease, or severe muscular convulsions become developed. When an operation cannot be completed in about one to two minutes, one or two inhalations of the concentrated vapour are given; then air is admitted, to be followed, if necessary, by further inhalations of the anæsthetic. It seems, however, safer to give only one dose, and to follow it by ether.

Terrier adopts the following method: A few drops are poured on at a time, all air being excluded, and more bromide of ethyl is added guttatim when the last dose has evaporated. When air-exclusion is not practised, this anæsthetic can be exhibited from a Skinner's or other mask. In this method a considerable quantity of the anæsthetic is used. Turnbull, who was one of the first to employ bromide of ethyl and to study its action, uses a towel folded into a cone. He pours into the cone 75 to 150 drops in the case of an adult, and 50 to 100

in that of a child. Kocher of Berne, according to Dr. Huggard,* employs this agent before ether. He suggests 15 to 30 grammes (3 to 6 drachms) at a time as one dose. As soon as the signs of narcosis appear ether is substituted. Very weak or anæmic people and young children are considered by Kocher to be bad subjects for this method. Alcoholism and Bright's disease are contra-indications to its use.

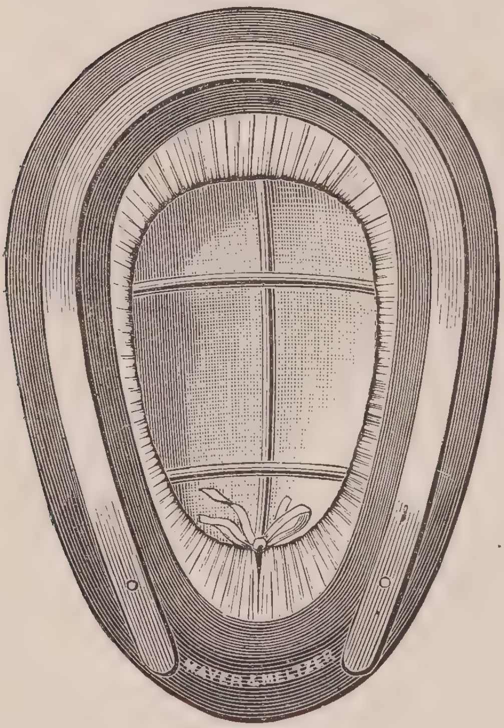


Fig. 55. Bromide of Ethyl Inhaler.†

Cases suitable for ethyl bromide.—Short Operations and those of Minor Surgery. — In dental operations the rapidity with which the patient shakes off narcosis renders bromide of ethyl of little more value than nitrous oxide, especially as it is less safe. Its use in dentistry has recently been strongly advocated in Germany. Dr. Silk also speaks favourably of it, but the frequency of more or less unpleasant after effects, which he states occurred among his patients, would seem to detract from its value in dentistry. Turnbull extols its use in midwifery, as it rapidly induces unconsciousness, and recovery is also speedy. It must not be forgotten, however, that when bromide of ethyl is given, even in small doses, much muscular spasm results, an undesirable phenomenon in accouchements.

* *Lancet*, September 12, 1903, p. 745.

† Made by Messrs. Mayer & Meltzer.

Dangers resulting from the use of bromide of ethyl.—Eight deaths are stated to have resulted from its administration, but some of these were in reality due to impurities contained in the sample used. Deaths have occurred, however, when the pure drug has been used; so I am disposed to agree with Professor Wood,* who regards this agent as equally dangerous with chloroform. Cases of death due to inhalation of bromide of ethyl have been recorded in which visceral degenerations were noted (Reich and Flatten). A. B. Kelly,† who has used this agent extensively, had thirty samples examined, and 60 per cent. were found to be unfit for anæsthetic purposes. The importance of obtaining absolutely pure specimens cannot be over-estimated. I believe Messrs. Duncan & Flockhart have undertaken the manufacture of this agent, so as to ensure its purity. Even pure bromide of ethyl, however, rapidly deteriorates when exposed to light, and must be then discarded.

Pental.—Trimethylethylene was described by Von Mering as an anæsthetic in 1887, and has been widely used in Germany for brief operations. Amylene, an agent which was employed with some success by Snow in 1856, agrees in many of its physical and chemical properties with pental. It is not now used.

Administration.—Pental is given with the same precautions as in the case of chloroform. Holländer ‡ employed Junker's inhaler in its exhibition. Mr. Constant, of Scarborough, has used pental in dental surgery, exhibiting it from a Clover's regulating ether inhaler. Dr. Stallard, of Manchester, has used pental in 150 cases; he also adopts Clover's inhaler, pouring in two drachms

* *Therapeutics*, 1905, p. 102.

† *Brit. Med. Journ.*, August 30, 1902.

‡ Holländer's "Pentalnarkosen, 1893," in *Deutsch. Med. Woch.*, No. 33, contains much information on pental, and should be referred to for further details

and excluding all air until unconsciousness is obtained. The lid reflex was only lost in deep narcosis. The breathing under pental becomes almost imperceptible; cyanosis and stertor are rare. The induction period is about 57 seconds, and the anæsthesia lasts 76 seconds.

After effects.—Muscular contractions, enfeeblement of the heart-action, and respiratory spasm were noted. Dr. Stallard has met with one fatal case. The dangers of pental are summarised by this observer: (1) Its insidious action renders it very difficult to avoid giving an overdose; (2) tendency to make the patient scream; (3) tendency to respiratory failure; (4) causes cardiac failure. Breuer (Vienna) had one threatened death from respiratory failure in 120 cases. He found the anæsthesia too slight for the reduction of dislocations. Both Schede * (Hamburg) and Sick † have noted casualties under pental. According to Kleindeinst, albuminuria, hæmaturia, and hæmoglobinuria may follow its inhalation. Cerna found marked fall of arterial pressure ensued upon its inhalation, while Gurlt's statistics gave pental a death-rate of three fatalities in 600 narcoses. In spite of these alarming statements we find Philip,‡ from his experience in the Kaiser Friedrich Children's Hospital, Berlin, strongly in favour of pental. He met with no serious after-effects.

The advantages claimed for pental over other anæsthetics appear to be more than counterbalanced by its dangers, which seem to depend upon the drug itself, and not upon any faulty method employed. At best it is only of use in short operations, and only when a superficial narcosis is required.

* "Congress der deutsch. Gesellschaft f. Chir. zu Berlin," *Berlin. klinische Woch.*, August 1, 1892, p. 784.

† *Deutsch. Medicin Wochen.*, No. 20, 1893, p. 486, and No. 22, p. 538.

‡ *Zeitsch. f. Kinderheilk.*, Bd. iii., iv., 1893.

Treatment.—The steps requisite to avert such accidents are similar to those described under "Accidents during the Administration of Chloroform."

Ethidene Chloride.

Ethidene chloride (ethidene dichloride), more properly ethilidene chloride, $C_2H_4Cl_2$, was first used by Snow in 1851, and Clover recorded 1,877 cases with one death. It is very liable to decomposition; its boiling-point is not uniform, while its physiological action is such as to indicate that it affects injuriously both respiration and circulation. Clover administered it, using his ether inhaler, and employed it in succession to nitrous oxide. As this anæsthetic is seldom now used, the reader should consult the writings of Clover, Liebreich, Langenbeck, Sauer, and Stiffen for details.

CHAPTER VII.

ANÆSTHETIC MIXTURES AND SOLUTIONS.

THESE are of two classes: (1) Combinations of the alcohol or ethereal series; (2) Alcoholic or ethereal anæsthetics used in conjunction with alkaloids or other agents.

The best known and most useful of the first class are:—

The A.C.E. MIXTURE.—Composed of 1 part alcohol sp. gr. ·838, 2 parts chloroform, sp. gr. 1·497, and 3 parts ether, sp. gr. ·735.

The C.E. MIXTURE.—Compound of 2 parts of chloroform and 3 of ether.

BILLROTH'S MIXTURE.—3 parts chloroform, 1 each of alcohol and ether.

The VIENNA MIXTURE.—1 part of chloroform to 3 of ether. Richardson * gives the formula for this mixture as 8 parts of ether to one of chloroform in hot, and 6 parts of ether to 2 of chloroform in cold, weather.

The MIXTURE recommended by Linhart.—1 part alcohol, 4 chloroform.

Professor Schäfer advocates a MIXTURE of 1 volume alcohol and 9 volumes chloroform.

"METHYLENE."—Methylic alcohol 30 per cent. and 70 per cent. chloroform (Regnauld and Villejean).

* *Asclepiad*, 1885, p. 274.

SCHLEICH'S SOLUTIONS—

	No. 1.	No. 2.	No. 3.
Chloroform . .	45 parts.	45 parts.	30 parts.
Sulphuric ether . .	180 ,,	150 ,,	80 ,,
Petroleum ether .	15 ,,	15 ,,	15 ,,

The **A.C.E. mixture,** which was originally proposed by the late Dr. George Harley, was strongly recommended by the Anæsthetics Committee of the Royal Medical and Chirurgical Society of London. They speak of its action as midway between that of chloroform and ether. It has been largely used in England, and although not without objections, is a good substitute in many cases when ether cannot be taken. The main drawback to the employment of this and all other mixtures is that the agents employed in their formation do not evaporate in the ratio in which the fluids are mixed, and hence it is impossible to be quite sure what percentage vapour of chloroform is being inhaled. The liability to this irregular evaporation may be minimised by evaporating one drachm or a half-drachm at a time. When used in these small quantities the evaporation discrepancy is of less importance. To obviate this difficulty, Ellis * proposed to blend the vapours of alcohol, chloroform, and ether in a specially constructed apparatus, and so administer a true vapour mixture to the patient. The arrangement he used is too complicated for practical purposes, and his method has never been received with much favour. In three chambers, known weights of the anæsthetics were evaporated; these chambers could be made to communicate at will with a common chamber, and from this the patient was anæsthetised. Dr. Gwathmey † has revived Ellis's suggestion and has invented a practical

* *Med. Times and Gaz.*, 1870, vol. ii., p. 107.
† *Med. Record* (New York), Oct. 14, 190

apparatus. This consists of three six-ounce bottles, in each of which are four tubes of various lengths, one reaching the bottom of the bottle, another just perforating the stopper. These tubes are assumed to represent four vapour strengths. Air or oxygen is forced through these tubes by means of a hand-pressure ball—as in Junker's apparatus—and the amount is assumed to be determined by the degree of compressure exercised. The accuracy of the instrument was tested by experiments, but these appear to lack precision, so that I think the dosage obtained must be accepted as being only approximate. A somewhat similar idea is carried out by Tyrrell's double bottle method. The vapours of ether and chloroform are made to enter a common face-piece by an arrangement whereby two Junker's apparatus are made to pump the vapours through the tubes (see below).

The late Mr. W. Martindale has proposed an admirable volumetric mixture, the ingredients of which evaporate almost uniformly. It consists of absolute alcohol, sp. gr. ·795, 1 volume; chloroform, sp. gr. 1·497, 2 volumes; pure ether, sp. gr. ·720, 3 volumes.

Method of employment.—This anæsthetic mixture may be given in a Rendle's mask, a cone, or by the open method. When a cone or Rendle's mask is used, it is best to use about a drachm, and add a fresh supply when the first has evaporated. I find Allis's inhaler also answers well. Junker's inhaler, fitted with the flannel mask, is very convenient for giving the A.C.E. mixture to children. With the open method, much ether vapour escapes into the surrounding air, causing inconvenience and delay in the onset of insensibility, and further rendering the mixture relatively rich in chloroform while deficient in ether. In the case of children and very nervous persons, it is a good plan to give the A.C.E. guttatim on a mask or corner of a towel, replacing it by the inhaler when the

patient has become unconscious. Although this solution is sometimes given from a "Clover's" inhaler without the bag, the method, I think, is not free from danger even if the inhaler is constantly lifted from the face and air very freely admitted.* The fact that chloroform is present in the mixture makes it obligatory that plenty of air be allowed the patient, to effect which the cone or inhaler should frequently be raised from his face. Both respiration and pulse must be carefully noted, as fainting and asphyxial troubles may occur during the employment of the A.C.E. mixture. The signs of anæsthesia are those given under "chloroform." Duskiness is common and is due to insufficient air. Stertor should not be permitted. Patients who will not tolerate ether often take A.C.E. well, but in its use it must be remembered that unless a considerable amount of air is given, respiratory difficulties are sure to arise.

After-effects are much the same as those of chloroform or ether, although they are commonly slight. Deaths have occurred during the use of the A.C.E. mixture, and have been attributed both to respiratory and cardiac failure. Physiologically the A.C.E. solution resembles chloroform antagonised by the alcohol it contains. This antagonism reveals itself in the maintenance of the height of blood-pressure, and in keeping the respirations at a force and frequency very little less than normal.

The C.E. mixture is simply the A.C.E. solution with the omission of the alcohol. It is employed in the same way as the A.C.E., over which it possesses no advantage.

The research of Schäfer and Scharleib † shows conclusively

* See a valuable paper by Dr. Edgar Truman, *Lancet*, Feb. 16, 1895, p. 403, and a further one on the same subject by Sir William Ramsay, F.R.S., *Transactions of Society of Anæsthetics*, vol. ii., p. 13, in which it is pointed out that this mixture, given from a closed inhaler, is unsafe on account of the irregular manner in which the constituent parts are given off.

† *Trans Roy. Soc. Edin.*, vol. xli., part ii., no. 12.

that the C.E. mixture is based upon a wholly fallacious theory that the alcohol in the A.C.E. mixture is merely a menstruum, and the ether in the C.E. mixture exerts a stimulant action upon the circulation. They prove that the C.E. mixture acts precisely like chloroform of similar strength, that the ether exercises no independent action—is, in fact, a mere diluent. Nor is this all. They found, further, that the A.C.E. mixture owed its undoubted merit wholly and solely to its alcohol (16·5 per cent.), while its ether was, as far as blood-pressure went, a negligible quantity. The proportion of 1 in 10 alcohol to chloroform in their hands gave better results than did the larger amounts of alcohol. In fine, their results indicate that the C.E. mixture is more dangerous than the A.C.E., is about upon a level with diluted chloroform, and when employed without complete admixture with air is to be avoided; that the A.C.E. mixture possesses no advantage over the alcohol chloroform mixture (1 in 10), and should be replaced by it. These remarks apply with equal force to **Richardson's mixture** (alcohol 2, chloroform 2, and ether 3 parts) and the **Vienna mixture** (chloroform 1, ether 3 parts).

Billroth's mixture (alcohol 1, ether 1, chloroform 3 parts) may be considered as an alcohol-chloroform mixture of 20 per cent. alcohol which, from what has been said above, possesses no advantages over the 1 in 10 mixture. If used at all it must be given in the same way as diluted chloroform, and with the same precautions.

Tyrrell * employs the **apparatus** depicted below to effect the **commingling** of air impregnated with the **vapour** of **chloroform** and that of **ether.** The tubes are so arranged that the administrator can

* *Trans. Soc. Anæsth.*, vol. i., p. 1, 1898,

give as much of each vapour as he decides is required for the case. One pair of bellows controls the two bottles, a Y-shaped piece with a little graduated tap on each bifurcation of the Y being inserted between, while a similar Y-shaped piece allows the passage of the vapour from each bottle to a single tube which is attached to the face-piece. Before commencing the

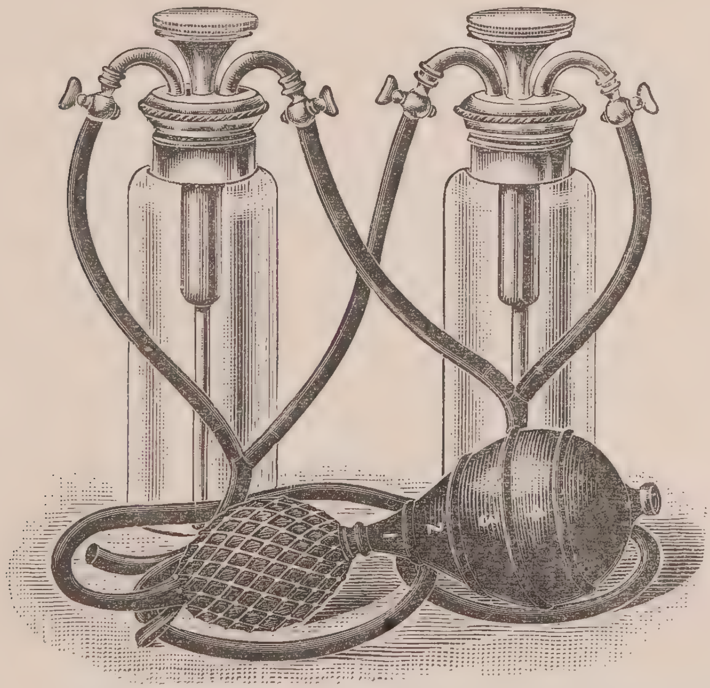


Fig. 56. Tyrrell's method of combining the vapours of chloroform and ether.

inhalation the tap controlling the ether supply is adjusted so that only as much ether vapour will escape as can be respired easily. In the case of a child less ether is allowed to pass. This tap is left in this position, but the tap on the bottle cutting off the ether is closed, and only opened if in the course of the administration of the chloroform, conducted on ordinary principles, ether is required.

Alcohol-Chloroform mixtures. — Schäfer and Scharleib * have shown the superiority of these over mixtures containing ether. The one they found most useful, as it produced chloroform effects, and yet antagonised its dangers as far as the fall of blood-pressure and enfeeblement of the respiration are concerned, is composed of **one volume alcohol** in **ten** of the **mixture**. It is administered in the same way as pure chloroform, and with the same precautions.

Linhart's mixture (20 per cent. alcohol) is employed similarly. It contains more alcohol than is necessary, and gives less good results than the 10 per cent. mixture.

Methylene, or " bichloride of methylene," is stated by Regnauld and Villejean to be merely a mixture of methylic alcohol (30 per cent.) and chloroform (70 per cent.). It is seldom used at the present time. It may be given from a Junker's inhaler. It is inferior to the above mentioned alcohol-chloroform mixture, and is less safe. Several deaths have occurred during its use.

Schleich's solutions for general anæsthesia.—The rationale of these solutions lies in the assumption that the rapidity with which anæsthesia can be obtained and the permanence of the anæsthesia depend upon the boiling point, or temperature of maximum evaporation of the agent which is inhaled. It is assumed that by altering the temperature of maximum evaporation, so as to make it nearly coincide with the blood heat, it would be possible to regulate the intake and elimination of the anæsthetic vapour in such a manner as to maintain anæsthesia without over-narcotism, since the elimination under such conditions would prevent accumulation of the anæsthetic in the blood. Schleich proposes three solutions:

* *Op. cit.*

No. 1 for light, No. 2 for medium, and No. 3 for deep anæsthesia. These are:—

	No. 1.	No. 2.	No. 3.
Chloroform . .	45 parts.	45 parts.	30 parts.
Ether (sulphuric) .	180 ,,	150 ,,	80 ,,
Ether (petroleum)	15 ,,	15 ,,	15 ,,
Boiling point .	38° C.	40° C.	42° C.

The petroleum ether employed must have a boiling point between 60° and 65° C., and a sp. gr. between ·670 and ·700, since the common commercial kind induces deleterious effects when inhaled for any time. Willy Meyer (New York) and Maduro (New York) have employed the solutions, and were favourably impressed by them, but their experience does not seem to have been that of others who have employed these solutions.

According to Rodman,* the induction of anæsthesia took from fifteen to twenty minutes. The solution, although causing some excitement, compared favourably with ether in this respect, and also produced more complete muscular relaxation. There was also less irritation of the mucous membranes. The early disappearance—presumably before true anæsthesia—of the reflexes, especially the ocular, is, he thinks, a drawback, as the anæsthetist loses a valuable guide. The patients, after inhaling No. 3 solution, became cyanosed, the pulse slowed and grew weak, the pupils were dilated, while the respirations were shallow and rapid. Eventually the cyanosis became general, the breathing infrequent and feeble and, with little warning, stopped altogether. This occurred in six cases which he witnessed, while in others profound circulatory depression, with heart failure, were seen. Retching and vomiting were, Rodman contends, as frequent as with other anæsthetics, nor was the return to consciousness more rapid or freer from inconvenience.

* *Med. Rec.* (New York), Oct. 1, 1898.

Schleich appears to regard the recovery as like that of one awakening from slumber. Upon the lungs and kidneys the effects were much the same as with ether. Bronchitis, followed by pneumonia, occurred in several cases, being in some instances fatal. Rhinitis and conjunctivitis were observed as sequelæ, and in three antecedently healthy persons albuminuria, with casts in the urine, followed the inhalation of the solution. Rodman further records a case in which heart failure of the most pronounced nature resulted from inhalation of No. 3 solution.* It would appear that after a somewhat extensive trial of Schleich's solutions their use has become very much restricted.

Wertheim's solution (1 part chloroform, 1 part petroleum ether, and 2 parts sulphuric ether) has been used in this country by Dr. Probyn Williams.† It was administered from a mask—a modified form of Skinner's frame—and the experience gained from a limited number of cases is said to be favourable. Dr. Silk's ‡ experience of Wertheim's solution has led him to believe that the petroleum ether which it contains is inoperative, so that the solution is practically one of sulphuric ether and chloroform. As such he considers it has some merits.

Chloroform and ether in various combinations and sequences.—A great variety of combinations and successions of these, besides those mentioned above, have been proposed from time to time, but need no special mention. (See chapters on Ether and Chloroform.) One point, however, must again be dwelt upon, and that is that either in the case

* See an article in *Year Book of Treatment*, 1899, p. 177.

† *Transactions of Soc. of Anæsth.*, vol. iv., p. 98. A note on a modified form of Schleich anæsthetic mixture by R. J. Probyn Williams, M.D., Harold Barnard, M.S., and Russell Howard, M.B.

‡ *Transactions of Soc. of Anæsth.*, vol. v., p. 138.

of chloroform given before ether, or *vice versâ*, great care and watchfulness must be employed, since in the one case the reaction from circulatory depression to circulatory stimulation, and in the other from circulatory stimulation to vaso-motor depression, may produce bad effects and even lead to accidents. Professor Julliard * regards the plan as one "combining the dangers of chloroform with the inconveniences of ether."

A.C.E. mixture followed by ether or chloroform.—See articles on A.C.E. Mixture, Ether, and Chloroform, respectively.

Nitrous oxide and ether.—This combination is fully described under "Ether," p. 148. It is the best method of producing general anæsthesia. When complete unconsciousness has been attained by giving nitrous oxide, the duration may be prolonged by allowing the gas to pass through the ether; or, by turning off the gas altogether, the patient may be kept anæsthetised by ether for a lengthened period. The objection urged by Terrier and Péraire † that the vapours are liable to explode is, I think, purely theoretical, unless through gross carelessness the mixture is allowed to become strongly heated.

Clover's gas and ether apparatus enables one to regulate the supply of gas or ether with a nicety and precision unattained by any other instrument. When chloroform is not given by means of an accurate regulating inhaler, it is an excellent and safe plan to induce anæsthesia by this method and maintain it by means of chloroform. The precautions and dangers incident to this method are those fully described in the chapters upon Nitrous Oxide Gas and Ether.

* "L'éther est il préférable au Chloroforme," *Rev. Med. de la Suisse Romand.*, February, 1891.

† *Op. cit.*, p. 180.

The chloride of ethyl and ether sequence is described on page 269. It is an alternative to the nitrous oxide-ether method.

Bromide of ethyl and chloroform.—The employment of these drugs *in succession*, similarly to nitrous oxide before ether, is, according to Terrier and Péraire, extremely useful. Otis (Boston) has suggested ethyl bromide 1 part, chloroform 3 parts, and alcohol 4 parts, and has employed it extensively in general and obstetric surgery.

Bromide of ethyl followed by ether.—This method is advocated by Kocher of Berne.

Chloroform vapour with oxygen.—This obvious combination was employed very early in the history of the anæsthetic. It has more recently been revived by Neudörfer and others. I have made many experiments with this combination, and although I cannot find any true physiological antagonism between chloroform and oxygen, such as is asserted by some, there is no doubt in my mind that for persons with tendency to become cyanosed or congested, the employment of oxygen with chloroform is most useful. I have used the oxygen *pari passu* with the chloroform without attempting a definite percentage dilution. Neudörfer employs 10 per cent. by the use of a special apparatus. A special apparatus is not, however, necessary. It is extremely simple, by connecting the oxygen supply bottle with a nasal or mouth tube, to give as much or as little of the gas as the patient requires. Kreutzmann makes use of Junker's apparatus, pumping oxygen instead of air through the supply tube. There is, however, a danger in this proceeding. The supply of oxygen to the patient prevents the appearance of cyanosis, and chloroform may be pushed until the respirations stop through overdosing the respiratory centre.

The value of oxygen given with chloroform consists in obviating any intercurrent asphyxial condition, causing rigidity, cyanosis, and impaired breathing. It does not antagonise the action of chloroform on the heart or nerve centres, although it protects the patient from the double dangers which arise when chloroform is inhaled while his blood is in a condition of undue venosity. The destructive properties of chloroform are still in action, and over-dosage is as liable to occur with as without oxygen.

Mixture of Chloroform or Ether with Alkaloids, etc.

Chloroform and morphine. (Nussbaum).—Nussbaum, of Munich, was the first to employ this method in Germany (1863). He injected morphine during chloroform narcosis. Claude Bernard had studied it experimentally some years later (1869), having had occasion to give morphine to a dog recovering from chloroform. The use of morphine to induce sleep before giving chloroform is usually attributed to two French surgeons, MM. Guyon and Labbé. Injections of morphine, gr. $\frac{1}{6}$ to $\frac{1}{2}$, or even in larger doses, given hypodermically half an hour before the inhalation of chloroform, are stated to possess the following advantages: Less chloroform is needed, while the narcosis is more prolonged. Drunkards, neurotic persons, and those who are but little amenable to chloroform alone, after a dose of morphine soon become anæsthetic. The patient is usually more completely relaxed and passive, the breathing is quieter, and it is stated (Kappeler) that the depressant action upon the heart is diminished. This statement is, however, hardly

borne out by modern research. The stage of excitement is shortened, although in some cases if the morphine is administered immediately before the inhalation the period of excitement is prolonged. Cerebral circulation while under morphine is markedly weakened, so that for operations involving the opening of the meninges and the cutting of the brain substance, this combination is most valuable. On the other hand, Horsley has pointed out, the use of morphine increases the danger of respiratory paralysis in patients whose respiratory centre is affected by disease.

Vomiting is more frequent when morphine is used. Poncet, from a wide experience during the Franco-Prussian war, abandoned the method, owing to the frequency with which prolonged stupor and dangerous depression of the temperature occurred after its use, and his experience coincides with that of Demarquay's experiments upon the lower animals.

Guibert de Saint-Brieuc* has employed this plan with great success in cases of difficult parturition.

After morphine has been injected, it is important to restrict the amount of chloroform given; indeed when the patient is once fully narcotised, very little more chloroform will be needed unless the operation be a very prolonged one. Care must be exercised that only a weak vapour is used, since the patient will take but little notice of its pungency, and so one of the usual safeguards is lost. When severe hæmorrhage is likely to take place into the pharynx this method is dangerous, as the patient is roused with difficulty, and the loss of reflex action increases the danger of blood entering the lungs.

Regnier asserts that the morphine, by lessening the

* E. Mergier, "Technique instrumentale concernant les sciences médicales," 1891, p. 25.

elimination of the chloroform, predisposes to over-dosage. He lost one patient when this method was used. Dastre points out the liability to respiratory failure when morphine is used.

Demarquay has very justly indicated that the chief danger of this method of mixed anæsthesia lies in not limiting the dose of the anæsthetic and of the alkaloid with sufficient care; large injections of morphine preceding chloroform administration certainly involve the risk of producing asphyxia through paralysis of the respiratory centre. The injection should be made, if at all, half or a quarter of an hour before the inhalation. If much albuminuria exists it is better to use chloroform without morphine. Under no circumstances should this method be employed for children, since morphine acts very deleteriously upon them.

Morphine, atropine, and chloroform.—It was pointed out some years ago that atropine, in paralysing the vagus, might be a valuable antidote to chloroform, by preventing reflex inhibition of the heart through the vagus. I have found the addition of gr. $\frac{1}{120}$ of atropine to gr. $\frac{1}{4}$ of morphine to be an advantage, when the later alkaloid is employed synergetically with chloroform. It must be noted, however, that the morphine antagonises the atropine and lessens its value as a safeguard against vagal inhibition.

This plan, which goes by the name of the Dastre-Morat method in France, is said by its inventors to be safer than Nussbaum's method. Aubert, of Lyons, employed it in practice and speaks well of it. The injection is made 15 or 30 minutes before the commencement of the operation. The mixture Dastre recommends is Morph. Hydrochlor. 10 centigrm., Atropin. Sulph. 5 milligrm., Aq. destill. 10 grammes, 1 cubic centimetre or 1·5 c.c. being injected.

The use of atropine in this way lessons the after-sickness, salivation, and bronchial secretion. Terrier and Péraire's experience at the Hôpital Bichat was, however, far from encouraging. Their patients were profoundly narcotised, were awakened with difficulty, subsequently passing into a restless condition, they became faint almost to syncope, cold, and blanched with feeble respiration.* Claude Bernard and Laborde employed narceine and other opium alkaloidal bodies with chloroform, but I have had no experience of their use.

Morphine and ether.—Julliard, of Geneva, in all prolonged operations gives a hypodermic of morphine (1 centigramme for men, half this dose for women) 20 minutes before the inhalation of ether. He restricts its use to adults. The method is said to possess disadvantages and to prolong the stage of excitement. It may induce very violent struggling and increase the after-headache, prostration, and vomiting. Kappeler, who has experimented with this mixed method, states that he has completely failed in several cases in which he attempted to narcotise patients with ether subsequently to hypodermic injections of morphine. My experience does not bear out Kappeler's assertions. Certainly in the case of the emphysematous the method possesses advantages.

Atropine before Chloroform.—Schäfer,† relying upon his experimental investigations, asserts that $\frac{1}{100}$ gr. to $\frac{1}{50}$ gr. of Atropine in the case of an average male adult, and given hypodermically half an hour before chloroform is inhaled, greatly lessens, if it does not remove, the greatest dangers of that anæsthetic. This dose will paralyse the vagus and so prevent vagal inhibition of the heart. The subject is dealt with subsequently in the chapter on "Accidents."

* *Op. cit., p.* 186. † *Op. cit.*

Chloroform and chloral.—The preliminary giving of chloral was first employed at the Hôtel Dieu by Dubois.*

Perrin used as large a dose of chloral as gr. 45 for adults, given one hour before giving chloroform.

Dastre gives 2 to 5 grammes of chloral an hour before administering the chloroform by inhalation.† He explains the action of the agents thus: the chloral, acting as an hypnotic, composes the patient to sleep, and the tranquillity and lethargy of the patient enable the administrator to maintain true anæsthesia by the use of a small quantity of chloroform. The plan has been fully tried by Dolbeau, Guyon, and others, and they find the patients remain cold, faint, and collapsed for hours after the inhalation, and are peculiarly liable to bleeding, owing to the relaxation of the vessels. There is no doubt in my mind that the method is fraught with danger, owing to the action chloral has upon the heart. Trélat adds **morphine** to the combination, and thereby, I think, increases its danger.

More recently **scopolamine** has been recommended for similar reasons. It is chemically identical with hyoscine. Terrier, who has employed this agent combined with morphine, injects gr. $\frac{1}{64}$ of scopolamine with gr. $\frac{1}{6}$ of morphine in m. 17 of distilled water. One injection is made 4 hours, the second 2 hours, and the last 1 hour before the operation. In many of the cases recorded the sleep thus induced sufficed, but in others a small quantity of chloroform was given at the time of the operation. The drug readily undergoes decomposition, increases hæmorrhage, and causes some muscular rigidity.

Cocaine and chloroform (Obalinski).—The

* "Anæsthésie Physiologique," par Dr. R. Dubois, 1894, p. 135.

† "Les Anesthesiques," p. 249.

plan recommended is to allow the patient to inhale chloroform in the ordinary way until he is slightly under its influence, and then to inject cocaine hypodermically. The dose is given as gr. $\frac{1}{3}$ to gr. $\frac{1}{2}$ of a 3 per cent. solution. It is claimed that less chloroform is required, and that fewer "after-effects" follow the use of the combination. However, cocaine does not antagonise chloroform, as is sometimes stated, but tends to increase the risk of heart failure, so that I think Obalinski's method is not to be recommended.

Rosenberg paints the nasal mucous membrane with cocaine before giving chloroform, as he contends this obviates reflex cardiac inhibition due to irritation of the fifth pair of nerves by the chloroform vapour.*

* *Berliner Klin. Wochensch.*, Jan. 7 and 14, 1895.

CHAPTER VIII.

ANÆSTHETICS IN SPECIAL SURGERY.

The choice of the anæsthetic has been discussed already; it now remains to consider such special methods and precautions as may be required to obtain satisfactory anæsthesia during the performance of special operations.

Operations on the brain and spinal cord.—The method which answers best when the brain is being operated upon is to employ chloroform from the Vernon Harcourt apparatus shown in fig. 34, p. 204. It is often extremely difficult to obtain anæsthetic sleep in patients who have taken large quantities of narcotic drugs, and the induction period, in these cases, is often longer than usual. Any attempt to shorten the induction period by using strong percentages is extremely dangerous. On the other hand, many persons who have to be operated upon for brain or meningeal disease are, at the time of taking the anæsthetic, very prostrate and semi-comatose, or suffer from the results of intra-cranial pressure. These conditions render interference with the circulation and respiration dangerous. The patient, when once anæsthetised, will often remain so with very little or even without any more of the anæsthetic. As a rule, when the intra-cranial pressure is relieved the respiration greatly improves, but until the cranium has been opened and the dura mater incised, breathing may be very unsatisfactory, and even may cause alarm if, owing to the steps of the operation, increased pressure occurs. When the breathing is at all hampered

the chloroform should be withheld altogether for a time. When the breathing improves more chloroform can be given, care being taken that the strength of the vapour is as slight as is consistent with maintenance of anæsthesia. In operations upon the **cerebellum,** the dangers of respiratory failure and shock are even more imminent, especially if there is pressure on the medulla. It may happen that, as soon as the trephine is applied, the breathing ceases. If the patient has been deeply anæsthetised, death is very likely to occur; but if 1 per cent. of vapour is being inhaled, the chances are in favour of the life being saved, since, as soon as the pressure is relieved, the breathing starts afresh, and the blood-pressure rapidly regains its normal height. I have known cases of cerebral and cerebellar abscess in which this respiratory failure occurred; as, however, only small quantities of chloroform had been inhaled the patients recovered, and the operations were satisfactorily completed. Ether produces too much vascular excitement in the meninges and brain substance, and so is contra-indicated in these cases. In treating the collapse—often very severe—I have found inhalation of oxygen, raising the temperature of the body by hot bottles and towels wrung out of hot water, and hypodermic injections of digitaline, to be the most valuable means to adopt. The circulatory depression is often extremely severe.

Operations upon the spinal cord present similar dangers, from the point of view of the anæsthetist, to those which occur when the brain is the seat of operation. In them, also, it often happens that, owing to the lesion in the cord, the respiration is embarrassed *ab initio* through paralysis of the muscles concerned in the respiratory movements. The posture necessary for the performance of the operation is a further source of difficulty and danger. Chloroform should be employed in these

cases, and in very dilute vapour, and oxygen freely given to avoid any asphyxial complication. When anæsthesia is established, no more chloroform need be given unless the patient begins to regain consciousness or shows signs of vomiting. It is often surprising how little—1 per cent. or less of chloroform—is required to maintain anæsthesia in these cases.

Anæsthetics in Ophthalmic Practice.

Most of the operations performed by ophthalmic surgeons are done with the aid of cocaine, eucaine, or other local analgesics, and the reader is referred to the chapter dealing with these substances. When general anæsthesia is desired, the choice falls upon chloroform, chloride of ethyl, the A.C.E., or gas and ether. As extreme stillness is a necessity in operations such as iridectomy, narcosis must be of the third degree, and great care must be taken that this is maintained lest coughing or straining occur, as this might prove most disastrous. Even with great care it is not always easy to prevent the patient passing into the fourth degree of narcosis. This contingency must be looked for carefully and prompt measures taken to avoid the great danger of overdosage. Many deaths have been caused by neglect of this. It is of paramount importance that the operation should not be commenced until the patient is profoundly narcotised. When complete anæsthesia has been obtained, the mask, or inhaler, can be lifted from the face, and as a rule the operation can be finished without any further inhalation being required. In very feeble or asthenic subjects, I have employed chloride of ethyl with success, following it with ether given in an atmosphere of oxygen. For brief operations chloride of ethyl answers

very well, but in cases in which after-vomiting is likely to prove dangerous chloride of ethyl should be avoided.

Anæsthetics for Operations about the Mouth, Jaws, and Respiratory Tract.

For the selection of the anæsthetic see p. 48. In Dental operations see pp. 67 and 314.

During the removal of loose sequestra from the jaws, excision of an epulis, tapping antral abscess, etc., very deep narcosis is not requisite, and chloroform may be given from a mask. If the operation occupies more than a minute or so, anæsthesia should be kept up after removal of the mask by the use of a mouth tube connected with a Junker's inhaler (p. 218). When the operation is very brief nitrous oxide, or ethyl chloride, will amply suffice. If ether is used in these cases, as it is in some parts of the United States, the anæsthetic must be pushed so that the patient's blood becomes strongly charged with it. When the inhaler is removed, chloroform can, if need arise, be given by a Junker's apparatus through a nasal or mouth tube. Oxygen is a valuable help when the patient is taking the ether, as it permits more of the anæsthetic being taken and obviates cyanosis, or venous congestion. When ether is to be relied upon solely for operations on the mouth or nose, it is essential to obtain a very profound narcosis by it before the operation is commenced. This can only be done by allowing a prolonged period of full inhalation. Oxygen given with the ether facilitates this, and ensures a more lasting and profound narcosis. I have on more than one occasion given ether, the circumstances of the cases contra-indicating another anæsthetic, for removal of the upper jaw, and found the method extremely satisfactory.

During the removal of the upper jaw the patient must be kept deeply under the anæsthetic for the skin incisions. A choice of several methods exists. In the case of feeble people or those broken in health by alcoholic excess the induction of anæsthesia may be brought about by chloride of ethyl and ether, chloroform being given subsequently from a mask. As, however, this plan may cause congestion and increase the after bleeding, I usually commence with chloroform, using a Vernon Harcourt's inhaler, and, when the third degree is reached, give a few breaths from a mask, continuing the supply of chloroform by means of a mouth tube and Junker's inhaler. Some persons are difficult to keep quiet with the mouth tube. To meet this, the mask should be applied, as opportunity arises, to supplement the vapour passing through the tube. When the skin flaps and soft parts are freely divided and dissected up, the patient must be allowed to enter the second degree of narcosis, so as to be able to cough and prevent blood entering the larynx, although he should be sufficiently anæsthetic as not to struggle. The management of these cases needs constant care and some judgment. The dangers the chloroformist has to guard against are—entrance of blood, teeth, portions of growth, spicules of bone into the larynx; and interference with the operation by the patient becoming partially conscious. If struggling occurs when much hæmorrhage is going on, the danger of the operation is increased greatly. The chloroformist should see that the spurting of blood from vessels is directed out of the mouth; that the tongue is not allowed to fall back; and that the air enters and leaves the lungs freely. If the patient's respiration is embarrassed from entrance of blood into the air-passages, the tongue must be drawn well out of the mouth, all blood mopped away and, failing relief from this, laryngotomy performed and

the air-passages cleared of clot; subsequently the tube must be kept free from clots, etc., by aspiration, or sucking them out from the tube. Inversion may be needed.

Removal of the lower jaw may often be done almost completely while the patient is under ether, the ether being given in the manner already described, and chloroform administered only just at the last when, in the course of the operation, the mouth is opened. This is an admirable method. Many surgeons prefer the use of chloroform throughout the whole operation.

In excision of the tongue the patient, having been anæsthetised by chloride of ethyl and ether, or by chloroform, one of the methods already described being adopted, chloroform is subsequently administered through a nasal or mouth tube. The same precautions with regard to hæmorrhage should be taken as in anæsthetising for removal of the jaws. When much bleeding occurs the patient must be guarded from deep narcosis. In Kocher's operation ether can be used until the floor of the mouth is opened, and the tongue drawn out of the wound; at this point chloroform is exhibited through a nasal or mouth tube. Many prefer the use of chloroform throughout the operation.

When small growths are removed from the tongue nitrous oxide or chloride of ethyl answers perfectly well. The nitrous oxide anæsthesia may be maintained by using the "injector," or Coleman's nasal apparatus, while the surgeon is operating, although the venous congestion which is incidental to these methods is a detriment.

Staphylorrhaphy.—The chloroform is given from a modified Junker until the third degree of narcosis is fully reached. The Whitehead's gag is then fixed, chloroform being inhaled through a mouth tube. The tongue depressor should be so arranged as not to

interfere with respiration. The chin is best tilted up a little, as, if it is allowed to drop, breathing is always hampered. Anæsthesia can be perfectly well maintained in this way until the operation is complete. Mr. Warrington Haward tells me he has used ether successfully for these cases, but I have no personal experience of its use in this connexion. The hæmorrhage being, as a rule, slight and easily controlled, there is no particular fear of blood entering the trachea, and further, as quietness is very desirable in the patient, full surgical narcosis should be maintained. Some surgeons employ the semi-inverted position for these operations, and this posture certainly lessens the danger of blood entering the larynx.

Operations on the respiratory tract. Laryngotomy or tracheotomy is best performed when the patient is under chloroform, although an operation without complications can be carried out quite satisfactorily when chloride of ethyl is given, provided respiratory embarrassment is absent. When dyspnœa exists, chloroform should be employed, its use being so restricted that the patient is only lightly narcotised. While complete anæsthesia is requisite, any dulling of the respiratory centre is to be avoided. In cases of diphtheria the heart is always profoundly affected by the disease, and is peculiarly liable to suffer from even slight excess in the strength of the chloroform vapour inhaled. It is very important in such cases to employ a regulating inhaler, so that the amount given can be accurately known and the supply cut off at any moment. These remarks apply with equal force to patients with goître. When the anæsthetic begins to take effect on such patients, stridor usually appears, and it is unwise to deepen the narcosis beyond the point at which restlessness is controlled. In cases of suppuration involving the tissues about the trachea, as in **angina**

Ludovici, the danger of suffocation is always present, and chloroform must be given most guardedly. As a rule, these patients, and those afflicted with goître, do not take ether well. Deaths have been caused by the use of nitrous oxide and ether for persons with obstructed breathing. These anæsthetics are inappropriate and should never be used for such cases.

Excision of the larynx. Thyrotomy requiring a preliminary tracheotomy may be performed while chloroform is given by sprinkling it on a flannel stretched across a funnel connected with a Hahn's tube, or by directing a catheter over the outlet of the Hahn's or ordinary tracheotomy tube, and pumping chloroformed air through it from a Junker's inhaler. An alternative is given below.

Rectal Etherisation in Oral Surgery.

For removal of the tongue, the jaws, and for staphylorrhaphy, especially for excision of the larynx, the rectal etherisation is far more convenient for the operator than the plans named above in which chloroform is used. The operation can be carried on without a break. However, as some alarming and even fatal results have occurred under the care of skilled anæsthetists, it must be admitted that rectal etherisation is not devoid of danger. In most cases, although not in all, the after-effects are slight and not lasting. I regard the method as a valuable alternative one in suitable cases. When much blood is likely to be effused into the buccal cavity, careful watch will have to be taken that it is efficiently sponged out, and does not enter the windpipe.* If the anæsthetist is engaged in

* Especially is this important if the anæsthesia is profound and the reflexes annulled.

watching the apparatus at the foot of the operating table, another observer should be stationed at the head to watch the respiration.

In all these cases the inverted posture of Trendelenburg may be usefully employed.

Removal of Post-Nasal Adenoids, Nasal Spurs, and Intra-Nasal Operations.

The removal of growths in the post-nasal region gives rise to troublesome bleeding. Chloroform, preferred by many surgeons, possesses the disadvantage that the patient remains longer under its influence, and so it is less easy during its use to avoid blood entering the air-passages. The narcosis should be very light, in order that the larynx may be protected by its reflexes against the entrance of blood. Deep anæsthesia in these cases is most perilous.

Many authorities assert that the anæsthesia obtained by nitrous oxide given with oxygen or air is sufficient for removal of post-nasal vegetations. In many cases this may be so, when the anæsthetic is carefully managed and the operation is rapid. I have found this method also may be supplemented by the use of ether with most satisfactory results. There is no objection to the patient being placed in a chair, *provided chloroform is not given.* In some nasal operations a lengthened period of anæsthesia is required; then chloroform must be used in succession to the gas and ether, and respired through a mouth tube. In delicate children who fear "gas," chloride of ethyl answers very well.

The patient, if sitting up, is given gas and ether by Clover's method. When gas alone is used, it is well to put a dental prop, or Doyen's gag, in position before commencing the administration, otherwise much valuable time is lost in attempts to open the mouth. When the patient is well

under ether, the induction being so managed that no lividity or congestion is present, the mask is removed, the gag inserted, and the operation commenced. If the patient becomes restless before its completion the mask can be reapplied, the head being tilted forward and flexed, so that the blood passes forwards and not into the air-passages. If the patient is reclining, chloroform can be given through a mouth tube as soon as the operation is commenced, the amount being carefully regulated by the requirements of the patient, and withheld entirely if any interference with breathing occurs.

As soon as the operation is completed the patient should be turned right over on to his left side and laid with the head in such a position that the blood must escape out by the nostril and mouth. Some surgeons keep their patients on their left side throughout the operation.

The introduction of chloride of ethyl has given us an extremely useful and readily managed anæsthetic for *brief* operations on the nasopharynx. It is not so serviceable, except as a means of introducing ether and chloroform, for prolonged and difficult cases, and had better be restricted to those which are unlikely to present complications.

Of course, when the cautery is used in the nasal passages, ether must be avoided. In cauterising the turbinate bodies nitrous oxide or chloride of ethyl can be used.

Anæsthetics in Dental Surgery.

The operations for which an anæsthetic is usually needed are :—

Extraction of teeth.

Lancing the gums, and tapping the antrum.

Extirpation of the dental pulp.

Filling when the dentine is abnormally sensitive.

In tooth extraction, nitrous oxide gas—alone, or with air or oxygen—is the safest and most convenient anæsthetic.

The technique of the use of an anæsthetic is fully described on p. 79.

As a rule, it is inadvisable to administer gas twice to the same patient at one sitting, but if such a thing is done warning of probable after-headache should be given.

Where prolonged anæsthesia is required, nitrous oxide may be given by the nasal method. I find it convenient to commence in the ordinary way with gas, or gas and oxygen, and, when the mask is removed and the operation commenced, I apply the nasal inhaler and continue the gas as long as is necessary. If the patient becomes dusky or jactitates, the inhaler is lifted for a breath and then is replaced. This plan is less useful in extraction of upper teeth, especially if the lip is short or pulled forward by a prognathous jaw. Chloride of ethyl is valuable in suitable cases for prolonged dental operations. With 5 c.c. or 8 c.c., according to the patient, an anæsthesia can be obtained lasting sufficiently long for clearing the jaws. *Chloroform should never be given to a patient sitting upright in a dental chair.* If it is deemed wise to employ chloroform, the patient should be seen at his own home, and in bed, and the anæsthetic administered with the usual caution. Indeed, I think it is best, in every case when an extensive dental operation has to be done under an anæsthetic, that it should be performed in the home of the patient and under ordinary surgical conditions.

Thoracic Surgery.

In the surgical treatment of empyema some difficulty frequently arises in the choice of the anæsthetic. For short operations, such as exploratory aspiration, nitrous

oxide with oxygen answers very well, and this mixture offers many advantages. It is given in the usual manner, but as soon as anæsthesia is obtained, oxygen is freely admitted. Many patients complain that the mask increases their distress and dyspnœa. Chloride of ethyl is free from this drawback and may replace the "gas" in these cases.

Prolonged operations.—Chloroform has caused in a good many instances dangerous and even fatal results from syncope, while ether sets up severe cough and respiratory distress. Godlee,* whose experience of these cases is very large, advocates chloroform provided it is given slowly, and not pushed beyond the second degree of narcosis. I believe that chloroform is, upon the whole, the safest anæsthetic in thoracic surgery, especially in the form of the (1 in 10) alcohol-chloroform dilution. It should be given by a **regulating inhaler,** and **oxygen** freely mixed with it.

For resection of ribs the patient is slowly anæsthetised, and as soon as he passes into the third degree the tissues are divided down to the rib. He is then passed into the second degree, and this suffices for the rest of the operation. If there is a large amount of secretion, the lighter the narcosis the greater will be the patient's safety. Any change of posture must be carefully noted, and if the breathing is impeded, or coughing excited, the patient must be replaced in the posture of greatest ease. It is often a good plan in very severe cases—*i.e.*, when grave fears exist owing to the condition of the heart and lungs—to push the anæsthetic to only the first degree, as far as possible maintaining a state of analgesia, and always stopping short of true anæsthesia. To combat these difficulties I have employed the method of rectal

* "Diseases of the Lungs," by Dr. Fowler and Mr. R. J. Godlee, London, 1898, p. 114.

etherisation (*q.v.*) in thoracic surgery, and have been pleased with the results, especially in the case of children. When an empyema communicates with a bronchus great care must be taken that the patient does not become narcotised so deeply as to hinder free coughing up of the pus in his lungs. A great danger arises, when the patient is turned on his sound side, lest the pus flow into the bronchi of the healthy lung. If this occurs when the patient is deeply under the anæsthetic, asphyxia must result. Any appearance of cyanosis should be accepted as a signal to lessen the depth of the narcosis.

Anæsthetics in Abdominal Surgery.

Complete relaxation of the recti and other abdominal muscles is imperative; great quietude and freedom from hurried respiration, coughing, and vomiting, are also necessary for operations upon the abdominal parietes or viscera. To ensure these conditions, chloroform, the alcohol-chloroform, or the A.C.E. mixture, is most suitable. During the incision through the parietes, the patient must be kept fully under the anæsthetic, subsequently a lesser degree of narcotism is needed until the final skin sutures are put in, when deeper anæsthesia will again be requisite. Great care must be taken, however, that the patient is not allowed to recover sufficiently for the supervention of vomiting. In operations upon the gall bladder and its ducts, and in the region of the upper abdomen in general, it is often very difficult to effect complete relaxation of the parietal structures. This difficulty is partly anatomical in origin and partly reflex, due to handling viscera. Very commonly sounds, almost like articulate groans, are caused reflexly, and that even when the conjunctival reflex is abolished, the light reflex sluggish and

the pupil contracted. These must not be allowed to mislead the anæsthetist or induce him to deepen narcosis, and so give an over-dose. In cases in which a large tumour or collection of fluid or gas is removed from the abdomen, and the heart—previously displaced—is allowed to right itself suddenly, there is especial danger of syncope, and precautions against this must be taken. The head must be kept low, and a small percentage of chloroform vapour given in order to limit the fall of blood-pressure. Although many surgeons prefer chloroform in abdominal surgery, it is by no means advisable to give it in all cases. When the patient is much collapsed, or is very feeble, I have found ether with oxygen a much better and safer anæsthetic. Certainly with management it is often possible to obtain with ether as good, and sometimes even better results, than with chloroform. It is necessary that the ether should be inhaled for some time before the operation is commenced, to allow time for complete muscular relaxation. When the case is very prolonged care is requisite to avoid too much ether being taken. This is easily accomplished, as, after having been once placed profoundly under ether, the patient requires but little more of the anæsthetic. In cases of intestinal obstruction it is well to perform lavage before the anæsthetic is administered. The plan I usually pursue is to commence with chloride of ethyl, or nitrous oxide, then give ether, substituting chloroform if the operation is a prolonged one. I employ a regulating inhaler. This method is also useful in extensive operations upon the kidneys.

The rigidity of the recti-abdominis muscles—the bane alike of surgeon and anæsthetist—is very commonly the result of cyanosis, itself caused by some reflex or other interference with respiration. I have frequently achieved relaxation of these muscles by giving oxygen freely with

the chloroform. In extreme cases I use ether and oxygen, since ether produces greater relaxation than chloroform, and I return subsequently to the use of chloroform. It has been urged that the use of closed inhalers is apt to provoke rigidity of the muscles by hampering respiration. I am convinced that such a statement is true only in part. A closed inhaler need not, if properly employed, cause any cyanosis. It is only a question of the patient's ability to fill and empty the bag attached to the inhaler, and any patient who is not very markedly collapsed will be able to do this easily; but if he cannot do so he is not in any need of further anæsthetic. This misapprehension about the use of closed inhalers has arisen from a faulty method of using them and from the practice of not admitting sufficient air. Persons who are collapsed, and whose respiration and circulation are, as the result of disease or surgical shock, in a feeble and almost failing condition, can be stimulated by freely pouring ether upon an Allis's inhaler or even upon a mask. As soon as they improve—and they will do so in a few minutes—ether and oxygen from a closed inhaler can be substituted with advantage, followed, if need be, by chloroform from a regulating inhaler. For skin incisions local anæsthesia by Schleich's infiltration method may be used, but the subsequent manipulation of the viscera generally causes pain and may induce vomiting and faintness These may demand the use of a general anæsthetic.

In the radical cure of hernia and inguinal colotomy, ether answers perfectly well. Both these operations can in some cases be done under local anæsthesia, but not if the patient is timid and liable to shock.

Pelvic Surgery.

For the usual gynæcological operations chloride of ethyl alone in very brief cases, or followed by ether for longer

ones, may be used. The lithotomy position, especially in obese subjects, is prone to cause very pronounced respiratory embarrassment and, in consequence of this, circulatory feebleness, not infrequently inducing syncope. I know of one case at least in which breathing ceased and the patient was only restored by being placed horizontal while artificial respiration was performed. C. J. Bond * (of Leicester) has advanced reasons for believing that the displacement of the heart due to posture produces marked circulatory changes. It is probable that the lithotomy position may cause dislocation of the heart, and that the syncope arising from this posture is due as much to interference with the heart's action as to embarrassment of respiration.

Operations on the bladder, such as prostatectomy, require deep narcosis to enable the surgeon to introduce his fingers into the bladder. I find the ethyl-chloride-ether-chloroform sequence is the best for such cases, and that it is imperative that the patient should be thoroughly relaxed *before* the operation is commenced. If this is not done, spasmodic contraction of the muscles may occur, which is very difficult to overcome when once established.

The Trendelenburg position, used both in abdominal and pelvic surgery, will sometimes give rise to difficulties somewhat similar to those which occur in the lithotomy posture. When the diaphragm is forced up, especially in the case of short, stout persons, duskiness with embarrassed breathing and cardiac distress may arise.† These should be watched for, and the position corrected before more dangerous symptoms arise. In feeble, anæmic subjects, the head-down position is often distinctly helpful, but in these, as in all cases, great care is necessary to avoid any jerk or suddenness in altering the relative positions

* *Brit. Med. Journ.*, Dec. 12, 1885.
† Mr Carter Braine has recorded a case in which œdema of the face became developed as a result of the inverted position.

of the poles of the patient's body. In some operations a rolled pillow is placed under the patient's back to push forward the liver. This is very prone to embarrass both respiration and circulation. It is better, when possible, to allow time for the circulation to right itself before the operation is proceeded with.

Rectal Surgery.

All operations about the anus and rectum are not only very painful, but excite reflex straining and spasm. In anæsthetising for such operations, profound narcosis is needful. The combination of gas and ether in most cases answers well, although it is necessary to give enough ether to induce absolute muscular flaccidity, snoring respiration, and widely dilated pupils—and further, to maintain deep narcosis to the end of the operation. Most authorities regard ether as the safest agent for these cases, since less reflex shock arises under it than under chloroform. The patients are commonly anæmic and in feeble health, and need much care and watchfulness.

In such severe operations as Kraske's a close watch has to be kept upon the pulse. The posture, the loss of blood, and the shock render these operations especially anxious ones for the anæsthetist. It is necessary to decrease the amount of anæsthetic given when the hæmorrhage causes material shock.

CHAPTER IX.

ANÆSTHETICS IN OBSTETRIC PRACTICE.

Choice of anæsthetics, stage when to be administered.—As a rule chloroform is preferable to ether. When an obstetric operation is to be performed, or when the patient is greatly depressed by hæmorrhage or shock, and when it is desired to promote uterine contraction, ether may be selected. Chloroform is preferable in eclampsia and in cases of retained placenta. The A.C.E. and alcohol-chloroform mixtures also answer admirably. Otis, of Boston, employs in obstetric practice a mixture of bromide of ethyl 1 part, chloroform 3 parts, and alcohol 4 parts; of this preparation he speaks highly. Snow advised that chloroform should be withheld until the *os uteri* is fully dilated and well-marked expulsive pains have appeared. He, however, made an exception to this rule when, during an earlier stage, the pains were very severe. When there is spasm of the cervix, if chloroform is given in the first stage for 20 or 30 minutes, the spasm relaxes and the pains, which were very severe before, become easier; as the patient recovers from the anæsthetic, labour is accelerated.

Spiegelberg extols the employment of an anæsthetic for neuralgia and cramps occuring during parturition.

In normal labour little chloroform is needed; if a very dilute vapour is inhaled the patient sinks into a quiet sleep, and her sensibility to pain is lessened. The

second degree (Snow) of narcosis is quite sufficient for ordinary cases. The uterine contractions are but slightly affected. Although during the pains the woman may groan and appear restless, her complaints are but slight, and as soon as the pain passes off she again falls asleep.

Rules guiding the administration:—

1. Quietude in the room is essential; fresh air should from time to time be admitted, and the patient's posture should be unconstrained.
2. Chloroform should be commenced when the labour is in its second stage if the pains are very acute, but if they are not it is best to wait until the fœtal head is on the perinæum. As a rule the chloroform should not be given during the intervals between the pains, unless the severity of the pains is very great, or it is deemed advisable to induce deep anæsthesia for the performance of an obstetric operation.
3. For nervous women and those who dread pain, also in cases where the perinæum is very rigid, chloroform should be used, to relax the perineal structures.
4. In the event of the patient becoming excited by the chloroform, whenever it is deemed necessary for the woman to be anæsthetised, chloroform should be pushed to full anæsthesia.
5. In protracted labour, when the patient is to be kept anæsthetic, it is better to intermit the inhalation, to avoid an injurious accumulation of the drug.
6. Deep anæsthesia must be obtained when an obstetric operation becomes necessary (Charpentier).
7. The advisability of giving an anæsthetic to a woman in labour when heart, lung, or kidney disease exists, must be determined by the same general principles which guide us in deciding under similar circumstances in surgical cases.

8. It is necessary when the patient is kept wholly or partially under an anæsthetic, to carefully guard against over-distension of her bladder.
9. It is inexpedient to awaken the patient to consciousness by artificial means, *e.g.*, slapping with a wet towel.
10. When the fœtal head bears on the perinæum, the anæsthetic should be given more freely, as it relieves the increased pain, and also relaxes the maternal passages, while it lessens the probability of rupturing the perinæum.
11. Should the patient be depressed or the pains sluggish during the administration of an anæsthetic, an occasional stimulant may be administered. This practice should be confined within narrow limits, and when pursued sal volatile is the best stimulant to employ.
12. If the anæsthetic appears to interfere with the progress of labour, it may be necessary to suspend its use for a time and re-administer it after an interval, or even to withdraw it altogether. Chloroform is best avoided if a meal has been recently taken, since the vomiting which is likely to follow will impede delivery.

Objections.—These, although strenuously urged by some, are probably more theoretical than real.

1. Chloroform is said to increase the mortality alike among mothers and children.

Statistics certainly negative this statement. It has been shown that the danger to the parturient is *cæteris paribus* in direct proportion to the amount of pain experienced, and since chloroform minimises the pain, it lessens the actual danger of childbirth.

2. It is asserted that it protracts the labour.

Dönhoff * gives the results of his researches with the tokodynamometer. Light anæsthesia under chloroform lessened, but deeper narcosis abrogated, uterine contractions. Hence, chloroform is the best anæsthetic in cases of threatened rupture of the uterus with transverse presentation and loss of amniotic fluid.

Deep narcosis renders the voluntary abdominal muscles lax, and so interferes with expulsive efforts. Very deep narcosis also paralyses the uterine muscular tissue. On the other hand, a womb, exhausted by frequent and ineffectual contractions, often will regain tone under chloroform and resume vigorous expulsive movements.

3. Rupture of the perinæum is said to be more frequent when chloroform is used, but both experience and *à priori* reasoning point to the reverse being true, since under chloroform the violence of the expulsive pains are lessened and the perineal structures are relaxed. The fact that, in cases of rigid perinæum, chloroform is given may account for the statement. The present practice is to produce deep narcosis in such patients, with the express view of saving the perinæum.

4. Complications are asserted to be more liable to occur when an anæsthetic is used.

This point was carefully investigated by the Chloroform Committee of the Royal Medical and Chirurgical Society, and it was found that chloroform, when properly administered, does not predispose to inflammation, puerperal convulsion, apoplexy, or other mishap.

Opinions differ as to whether it predisposes to imperfect contraction of the uterus and so to *post-partum* hæmorrhage. The answer to this question depends, first on the degree of narcosis arrived at, and secondly on the length of time allowed to elapse before its

* *Arch. f. Gynäkol.*, *Bd.* 42, p. 305.

use, and thirdly on the duration of its employment and especially after the birth of the fœtal head. It is also highly important that the patient's respiration should be free and unhampered by her posture. Lactation is not injuriously affected, nor is the child in any way injured.

Convalescence, so far from being delayed, is actually accelerated by the use of chloroform in childbirth. This is probably explained by the fact that when an anæsthetic is used the nervous system is protected from shock (Sansom).

Method of exhibition.—When chloroform is employed the open method is the simplest, admitting as it does plenty of air. A little chloroform may be sprinkled on cotton-wool in a glass tumbler, and the patient allowed to hold this, so that when she grows drowsy the improvised inhaler drops from the hand. Care must be taken, if lint or a towel is used, that the face does not fall over the chloroformed cloth, or the breathing become impeded by the pillow or bedding. The Vernon Harcourt inhaler is excellent in labour. The body of the instrument is hung over the back of the bed and the face-piece connected with it by a length of flexible tubing. The patient holds the mask over her face as long as she is conscious, and as soon as her grasp relaxes the mask falls away from her.

"When deep anæsthesia is required it is best to have a skilled administrator" (Chloroform Committee).

When chloroform, or the A.C.E. mixture, is administered by a person who gives himself up solely to this duty, the use of the Vernon Harcourt regulator, or of Junker's inhaler fitted with the glass mask (see p. 215), has the advantage of allowing less escape of vapour into the room, so that the air is kept more pure. This is especially

important when the chamber is lighted by gas or oil lamps (see p. 180).

In the First Stage of Labour, chloroform or the A.C.E. mixture, if required at all, should be given intermittently and in small quantities, except in the case of spasm of the cervix, when complete narcosis is needed. As a rule the first degree of narcosis is deep enough. The patient is conscious, but only slightly alive to painful sensations. If any excitement and disorderly conduct follow, the patient must be allowed to recover her self-control. Some persons need more chloroform than others, so that the administrator must decide each case upon its own merits, and further must be guided by his own observations, and not influenced solely by the patient's cry of "Give me some more." Women frequently repeat this phrase when almost unconscious, and unaware of preferring any request. However, chloral in grs. 15 until 30 to 40 grs. have been taken is better than chloroform in the first stage, and lessens the amount required later on.*

In the Second Stage, chloroform should be given only during the pains, and then merely to slight narcosis, since the woman needs the use of the abdominal muscles. At the stage of labour when the head is traversing the perinæum, deeper narcosis is needed to relax the soft parts, whilst at the last, as the head emerges through the vulva, chloroform should be freely administered.

When Instrumental Procedure is requisite deeper narcosis is needful, and especial caution is required in order to prevent the patient being made simply excited and rigid—a condition alike dangerous to the mother and child. In this stage the narcosis must be deepened and true anæsthesia obtained.

* When chloral has been given in the first stage, caution must be practised if chloroform is administered later. If the patient is drowsy and obviously still under the influence of chloral, very little chloroform should be used.

Obstetric Operations.

For *Turning* and instrumental deliveries, if an anæsthetic is employed, full anæsthesia is requisite and may be obtained either by chloroform, the A.C.E. mixture, ether, or by Otis's mixture. In deep narcosis from chloroform the parturient is probably placed in the same danger of overdosage as when anæsthetised for any surgical operation. Many practitioners employ the A.C.E. mixture in all their obstetric cases, and give it from a cone, or Rendle's mask. Ether is but little used in this country in obstetric surgery. It is sometimes urged against it that it does not relax the uterine tissue so effectually as chloroform. If this objection is valid it tells also the other way, as under such circumstances, hæmorrhage would be less likely to be severe. The ether effect, moreover, passes off more rapidly.

For extraction by forceps narcosis sufficiently deep to keep the patient quiet is needed. Some authorities prefer the use of ether in these cases.

Craniotomy.—Hour-glass contraction.—Retained placenta.—In these cases complete relaxation is necessary, but as the patient is often very collapsed, great care has to be taken that the anæsthetic is not unduly pushed.

Puerperal convulsions.—Chloroform was formerly used in all cases of convulsions associated with labour. It is, however, contra-indicated in apoplectic seizures. The modern practice is to use morphine, hot-air baths, etc., and only to give chloroform if other means fail. It is believed that prolonged inhalation of chloroform produces a deleterious effect upon the patient.

After-Effects.

After prolonged chloroformisation dryness of the mouth and throat and great thirst are sometimes complained of,

and can be relieved by sipping hot water and wiping the tongue with glycerine and borax, or by sucking thinly sliced lemon.

Vomiting is rare; faintness, excitement, and headache have sometimes been manifested, but as a rule few unpleasant results follow the use of chloroform in childbirth.

CHAPTER X.

THE ACCIDENTS OF ANÆSTHESIA, AND HOW TO TREAT THEM.

Before considering in detail the accidents of anæsthesia, it may be useful to indicate what precautions should be taken to obviate their occurrence.

Accidents arise from the following, among many causes :—

(1) The selection of an unsuitable anæsthetic : *e.g.* (*a*) nitrous oxide gas for a patient with obstructed breathing due to inflammatory swelling, œdema of the larynx, of the pharyngeal structures, or deep tissues of the neck ; (*b*) ether for a patient whose bronchial tubes and pulmonary alveoli are choked with secretion ; (*c*) chloroform for a patient whose heart is beating feebly and blood-pressure is markedly low.

(2) Faulty preparation of the patient. When directions are given about the diet, clothing, and regulation of the patient's bowels, too little attention is often paid to the effects likely to result from the anæsthetic. Weakly subjects, and especially children, are frequently left too long without nutriment, or are allowed indigestible food. Beef-tea, for example, is sometimes ordered to be given at unsuitable times—*e.g.* 5 a.m. or 6 a.m. It is very much better to diet the patient with care for one or two days before the anæsthetic is given. Alcohol given before the anæsthetic is inhaled is always harmful. It is, in my experience, better to rely upon the stimulant action of hot water taken three hours before the operation : it may be

flavoured with tea. Rectal feeding is far better for weakly subjects than food taken by the mouth. It can be employed to within an hour or so of the operation.

Weakly patients should not have strong aperients administered on the night before an operation. It is better that such purging as may be required should be done a day or so previous to that on which the anæsthetic is to be inhaled. Even an enema used just before the operation in some patients may produce prostration. An equally important matter is the maintenance at the normal height of the patient's temperature, as this lessens shock. Loosely fitting warm clothing should be arranged to cover the chest, abdomen, and limbs. The room in which the operation is performed should be kept at 65° F., or even 70° F.; but thorough ventilation is essential. It is equally necessary to warm the room into which the patient is carried after the completion of the operation. Many cases of collapse attributed to ether bronchitis are really due to the neglect of this precaution.

To anæsthetise a patient in a bed, and then to carry him into another room for the operation, is, I think, a dangerous proceeding. If circumstances exist which render this unavoidable, the utmost care should be used to avoid rough or unskilful lifting. The "head lower than the body" posture **must** be preserved in carrying: jolting and jerking **must** be avoided.

The utmost attention should be paid to the posture of the patient when on the operating table. It is easy to observe or ascertain in what posture he lies when breathing with the greatest ease, and, as far as the requirements of the surgeon permit, this position should be adopted for the patient when he is placed upon the operating table. This is especially important in the case of patients suffering from goître, heart disease, aneurism, empyema, obesity, large

abdominal tumours, and in those who are very old or very feeble.

Preparations should be made for possible contingencies. Sterilised tracheotomy instruments should be ready at hand. Cylinders of oxygen must be in the room. Tongue forceps, gags, transfusion apparatus, and warm normal saline or Locke's fluid may all be needed in cases where severe operations are contemplated, or the condition of the patient is critical.

It is often wise, especially in the case of mouth breathers, to place a dental prop between the teeth before administering the anæsthetic. It must, of course, be secured by fishing-line attached outside the mouth. The practice of setting tongue forceps on the tongue as a routine measure is unnecessary, and causes pain after recovery from the anæsthetic. When it is necessary to keep the tongue forward throughout the course of a prolonged operation, the best and least painful plan is to pass a fishing-gut ligature through the tip of the tongue and have it held.

Silence and avoidance of all noise must be enjoined.

The attention of the anæsthetist, of course, must be given solely to his own business. However desirous he may be to "lend a hand" as an assistant to the operator, he should resist the temptation and restrict his energies to his peculiar province. He has quite enough to do, and while handling the inhaler he cannot be surgically clean. It is important to see that the apparatus for anæsthesia is properly cleansed before use, and that the agents used are fresh and in their respective bottles and places. If the patient is lifted or moved, the anæsthetist should withdraw the inhaler during the change of posture, and should redouble his vigilance, as many dangers may arise at such a moment—*e.g.* syncope, vomiting.

In this place I may again caution against giving

chloroform in a small room in which illuminating gas or a lamp is burning. The decomposition of the anæsthetic, arising from the burning of its vapour, will be a sure source of danger to the patient and those engaged in the operation.

The use of the actual cautery.—Patients can inhale ether or chloride of ethyl before the use of the cautery in their air-passages. If a breath or two of air is allowed before the cautery is applied, there is no danger of the expired air exploding, which contains some vapour. Dr. Inglis Clark was kind enough to make some careful experiments with chloride of ethyl in this connection, and his results appear to accord with my clinical experience.

I. Accidents connected with Respiration.

Anatomical conditions such as cicatrices dragging down the skin and so fixing the larynx,* goîtres, and intra-laryngeal growths, may cause dyspnœa and alarming interference with respiration, as soon as the patient is partly under an anæsthetic. Faulty position of the patient's head may lead to similar accidents. The dropping of the chin upon the breast and the over-extension of the head while the jaw is permitted to fall are examples of faulty posture. Dyspnœa arises when, through spinal disease, the thoracic muscles are paralysed and the respiration is entirely diaphragmatic. As a rule the difficulty in respiration becomes much exaggerated in narcosis.

Foreign bodies may become loose in the mouth, and either get drawn into the larynx and thence into the

* I have met with several such cases, especially troublesome when the mouth and chin are dragged down to the chest, and when the tongue is fixed to the floor of the mouth. Dr. Guthrie narrates some typical instances in his thoughtful brochure, "Chloroform-Narcosis in Children," p. 53

trachea, or may become impacted, and so set up laryngeal spasm.*

False Teeth.—Small plates are especially dangerous, and obdurators, pivoted or loose teeth, may also become sources of peril. During an operation teeth, or pieces chipped off teeth, may fall back; and even portions of epitheliomatous or other growth, blood clot, pus from the bursting of post-pharyngeal abscesses, blood from epistaxis, detached tonsils and turbinate bodies which have slipped from the guillotine or turbinotome, nasal polypi, vomited undigested solid food, tobacco plugs, gags, portions of snapped-off forceps, and bits of sponge may obstruct breathing. Profuse salivation associated with increased secretion from the bronchi causes respiratory difficulty, and the patient becomes suffocated by his own secretion, unless the gravity of the situation is realised and prompt measures are adopted to remedy the danger. When the tongue is partially removed, the stump is liable to fall back and cover the glottis; and similarly, after removal of a portion of the lower jaw, the whole tongue is often carried back by its own weight. This may also occur in deep narcosis, even when the jaw is intact. The finger inserted in the mouth during tooth extraction often pushes the tongue back and complete occlusion of the air-way results unless this is noticed and remedied.

Precautions.—All loose bodies should be removed from the mouth before operation. The anæsthetist should ascertain if the patient has taken any solid food on the day of operation. It is a good rule in dental surgery never to operate upon the second tooth, when extracting several teeth, until the first tooth extracted is known to be *out of the mouth*; and care should be taken that the forceps are

* A round worm vomited from the stomach has under an anæsthetic passed into a bronchus and caused asphyxia.

freed from the tooth just removed before they are employed again. Gags and sponges should be securely tied to a long string which hangs outside the mouth. A Carter's oral spoon held in the mouth during tooth extraction prevents teeth falling back and being drawn into the larynx.

Treatment.—In the event of any foreign body becoming loose, the teeth must be separated by a mouth opener, a gag inserted, and the substance sought for with the finger. The patient's head and shoulders should be lowered, and efforts should be made to excite the laryngeal reflex by drawing forward the epiglottis by means of a bent tongue depressor or forceps. Slapping the back certainly aids. In prolonged operations, when possible the head should be placed on its side, to obviate the effect of the weight of the tongue in carrying it back, and also to facilitate the expulsion of blood. When bronchial secretion is profuse, and when blood, pus, etc., have been aspirated into the trachea, the patient's head is to be turned to the side, and, if a dental prop is not already in position, the mouth must be opened and the pharynx mopped out, When these measures are obviously ineffectual, the patient must be inverted and the secretions allowed to drain out, their passage being assisted by pressure upon the chest. Schäfer's method of artificial respiration is applicable to all such cases.

The following record of cases well illustrate this point. The patient suffered from empyema, the abscess communicating with a bronchus. The lad was anæsthetised by the rectal etherisation method. When anæsthesia was established, great dyspnœa appeared, owing to the pus from the abscess flooding both lungs. Inversion led to the draining away of a large amount of pus, and the operation was performed, the boy making a good recovery.

In the case of a patient, a short-necked, thick-set man,

to whom I gave ether for an examination, so much mucus was secreted that respiration was dangerously affected. Inversion and pulling forward the tongue led to the escape of a large quantity of fluid and relief of the dyspnœa.

In the case of a **solid body** entering the air-passages, unless it can be seen and removed by means of forceps, the air-way must be opened and the occluding substance, if possible, removed. In some cases the dyspnœa which at first threatened life, passes off owing probably to the position of the foreign body becoming altered. When this happens, it is better to delay surgical proceedings and subsequently perform a formal operation at a suitable time; but as Godlee points out, "the inconvenience of an early tracheotomy and the resort to the usual methods of search are not for a moment to be weighed against the possibly irremediable damage that may be done by even a few weeks' residence of a foreign body in a bronchus."*

When teeth, fragments of teeth or of metal stoppings, enter the air-passages, cough of a distressing character is set up. This either increases, and if the cause of obstruction is not expelled the dyspnœa calls for immediate relief by tracheotomy and inversion, or the immediate urgency may pass off. Later on the foreign body may be coughed up, although sometimes it may give rise to an abscess, subsequently to be expectorated; in other cases local septic pneumonia of painful chronicity is developed. Recorded cases have terminated fatally after prolonged illnesses, so that no pains should be spared to avoid this grave complication. Bicuspid teeth of the lower jaw are especially liable to fly from the beaks of the forceps and occasion the accident now under consideration, so that when these teeth are being extracted the mouth spoon should always be employed.

* *Trans. Med. Chir. Soc.*, vol. lxxix., p. 206

Vomited matters.—When, through the exigencies of the case or inadvertence, food has been taken within a few hours of the administration of an anæsthetic, vomiting is pretty sure to occur, either when the operation is proceeding or as the patient is commencing to regain consciousness. There is great danger lest vomited matters be drawn back into the larynx, leading to asphyxia.* In patients who are necessarily operated upon after having taken food, it is certainly wise to wash out the stomach either before the inhalation or as soon as the patient is sufficiently insensitive to permit the lavage without struggling.

Respiration may also be **hampered** by the posture † of the patient, by pressure upon his chest due to assistants leaning upon him, or to tight bandaging. In edentulous persons, especially if nasal stenosis exists, the lips are sucked in during inspiration, and often cause great respiratory difficulty, cyanosis, and inspiratory dyspnœa. This frequently arises before the patient is fully under the anæsthetic, and prevents his passing completely into the third degree of narcosis. It is at once relieved by inserting a gag, which keeps the lips apart and allows the anæsthetic to be inhaled. When placed prone or upon the side, feeble people, and those who are fat or emphysematous, or who have fluid in their chest

* The following case illustrates this danger: A hospital patient requiring a minor operation was instructed to abstain from food and present himself in the evening for the house surgeon to operate. The operation was performed—the patient being skilfully anæsthetised by a resident house physician; but during recovery he vomited, and large masses of undigested meat were taken from the mouth. Asphyxia being imminent, laryngotomy was performed, but the patient died, and the necropsy showed that a mass of meat had entered the trachea, and lay at its bifurcation, occluding the bronchi. It transpired that the man had, in spite of explicit directions to the contrary, partaken of a heavy meat dinner just before coming to the hospital.

† A useful paper by Dr. Hewitt and Mr. Sheild may be consulted on the subject of posture under an anæsthetic. See *Trans. Med. Chir. Soc.*, vol. lxxix., p. 1.

—one lung being more or less hampered—must be carefully watched, as the mechanical interference with breathing in these cases has caused fatal accidents. The complication is peculiarly liable to occur in the case of children, and especially in that of rickety infants, whose respiration is very commonly feeble. Gradually failing respiration, leading ultimately to cessation of breathing and associated with deepening duskiness, may arise from too little air being given or a slightly excessive percentage of anæsthetic. It is not uncommon when such mixtures as the A.C.E. or C.E. are used. To relieve the condition, the inhaler must be withdrawn, the mouth opened, and rhythmic traction made on the tongue (Laborde's method), supplemented by one or more vigorous compressions of the chest. These measures as a rule suffice for minor degrees of respiratory difficulties under anæsthetics.

In cases of intestinal obstruction the operation is an added danger, due to the regurgitation of the contents of the stomach and intestines into the mouth, and their subsequent aspiration into the air-passages.* This is not a true vomiting, but is a natural result of reversed peristalsis. As soon as the anæsthetic takes effect and lessens the contraction of the cardiac and pyloric sphincters, the intra-abdominal pressure becomes relieved by unloading the intestinal contents upward along the line of least resistance, instead of along its normal route. When this regurgitation occurs, every effort should be made by turning the head to the side to divert the regurgitated fluid away from the air passages. Lavage, frequently repeated, when practicable, should be performed before the anæsthetic is given.

* There is a similar danger while artificial respiration is being performed. Undue pressure made upon the abdominal contents may induce expulsion of the fluids contained in the stomach and intestines ; and thus the efforts to produce expiration may pump vomitus into the pharynx, and those of inspiration aspirate it into the air-passages.

The insertion of a gag between the teeth before giving the anæsthetic is an additional precaution which is useful. The anæsthesia should not be deep until the abdomen is opened, as it is important that the larynx should maintain its sensitiveness up to this point.

Pus or other **fluids** expelled from the **lungs.**

During operations for the relief of pulmonary or hepatic abscess, hydatid cysts, or of empyema, the patient may expectorate or otherwise expel large quantities of pus, blood, or other fluids, daughter cysts, etc., from the seat of disease, and these may, unless care is taken, pass into the lungs and interfere with respiration. As a rule patients clear their lungs of accumulated secretions in the early morning, and this is the safest time for the induction of anæsthesia. Similarly extensive hæmorrhages from phthisical vomicæ may occur and lead to intense dyspnœa. Beyond being prepared for such emergencies, and maintaining so slight a narcosis that the patient does not lose his power of coughing up the intruding material, little can be done. Posture is of much importance; the sound lung should be kept uppermost and the patient turned towards the diseased side. Artificial respiration performed by the usual methods is extremely dangerous in these cases, as it pumps the fluids into the pulmonary lobules and effectually asphyxiates the patient. The "Schäfer" method, which is described below, is less open to this objection, and may be employed in these cases. Ammonia fumes, perflation with oxygen, aided by compression of the sound side of the chest between the hands, one placed on the back and one in front, offer the best hope of assisting the patient to expel the foreign material from his air-passages.

All general anæsthetics eventually **paralyse** the **respiratory centre** in the medulla oblongata, and

so cause cessation of breathing; but some act more rapidly, and may induce spasm of the glottis if the vapour is too strong. When spasm is excited, no air enters the lungs, but irregular thoracic movements persist. Spasm of the larynx certainly may occur from chloride or bromide of ethyl, ether, or chloroform vapour, and, it is stated, from nitrous oxide gas. Cases occur in which the patient, either as the result of some pungency of the vapour inhaled, or because some of the anæsthetic vapour having become condensed comes in contact with the laryngeal mucous membrane, coughs with extreme violence, expiration becoming weaker and weaker and inspiration ceasing. This state culminates in spasm of the glottis, cyanosis, and urgent dyspnœa. The head must be extended; the tongue seized and drawn rhythmically forward, and pressure made upon the *lower* ribs. Oxygen inhalations will often relieve the spasm, and should be given when the spasm is sufficiently relaxed to permit the gas to be inspired. As a rule the spasm passes off rapidly, being relieved by the admission of air, but it may be sufficiently severe to need laryngotomy. Phosgene gas, the result of the decomposition of chloroform, which is evaporated in the presence of lighted gas, or even of a coal or a gas fire, may cause laryngeal spasm. Chloroform also acts upon the larynx in another way, whereby the air-passage becomes occluded—namely, by the closure of the arytæno-epiglottidean folds (Lister). In this case respiratory movements persist, although no air enters the chest.

Patients may be actually asphyxiated by the administrator excluding all air; and this may occur with any inhaler, unless care is taken and the colour of the face watched.

Cyanosis which is due to respiratory embarrassment should be watched for, and remedied by giving air or oxygen. Feeble breathers will often become slightly blue

even when inhaling low percentages of an anæsthetic. If the respiration is not stimulated by fresh air, it will grow weaker and finally cease, although prompt recourse to artificial respiration will restore it. This increasing enfeeblement of respiration should never be allowed to pass unnoticed or unrelieved.

Treatment.—In the case of a foreign body being free in the pharynx, the tongue should not be pulled forward, otherwise the tooth, or whatever it is, may enter the trachea. If the foreign body can be felt to be fixed, its removal must be attempted with laryngeal or œsophageal forceps, or with a snare. When the obstruction cannot be reached with the finger, the patient should, if conscious, bend with his head very low, breathe air softly, and expire or cough forcibly while his back is slapped. This often causes the foreign body to be expelled. Failing these measures the patient should be inverted, with the view of dislodging the foreign body. When this does not succeed, and if suffocation be imminent, laryngotomy must be performed. When the glottis has become occluded by the *falling back of the tongue*, pushing forward the lower jaw, so that the lower teeth lie in advance of the upper, will, by carrying the base of the tongue and epiglottis forward, open the air passage. This is best done by pushing the angle of the jaw forward, at the same time depressing the chin to prevent the lower teeth engaging behind the upper ones. Considerable interference with respiration may arise from the lips closing upon the teeth. Inspiration is absent, although a certain amount of expiration is carried on. The same obstruction often occurs in edentulous persons, the lips being drawn in and acting like an expiry valve. Nasal stenosis is commonly the cause of this difficulty, and its relief is obtained by opening the mouth and inserting a gag between the teeth or gums. There is sometimes masseteric

spasm associated with the condition, and some difficulty may be met with in the attempt to open the mouth. In persons with thick necks, and in cases of angina Ludovici, when the anatomical conditions cause dyspnœa and cyanosis, if the jaw cannot be sufficiently advanced, it is necessary to drag the tongue forward with forceps, and if the teeth are firmly clenched, as they often are in semi-asphyxial states, they must be first forced apart and a gag inserted.

Dr. Benjamin Howard has advocated the method of placing the head in extreme extension in order to obtain the maximum degree of patency of the upper air-passages during narcosis. Professor Wood, however, contends that a better plan is to place the index fingers of each hand on the cornua of the hyoid bone, and the middle fingers against the angles of the jaw. The fingers should press forward and upward, thus extending the head on the neck and thus opening the glottis. If this does not succeed, he recommends fixing a tenaculum far back into the base of the tongue and drawing it forward.

It should be remembered that when a patient is coming out of chloroform, and is about to vomit, the **glottis becomes closed,** and this may cause marked cyanosis. However, this state is at once relieved by the act of vomiting, and calls for no special treatment. In delicate subjects it is liable to be associated with marked circulatory depression, in some cases leading to actual syncope.

When **spasm** of the **larynx** results from inhaling an anæsthetic, and persists after drawing forwards the tongue and hooking up the larynx, laryngotomy must at once be performed. No formal operation is necessary ; the crico-thyroid membrane is incised, and a laryngotomy tube inserted. It is suggested by some that inhaling chloroform relaxes the spasm ; but this plan is of course useless if

the rima is quite occluded, and its adoption may involve loss of valuable time.

Ether inhalation, when the ether vapour is forced upon the patient in too concentrated a state, may set up some **spasm.** This, although causing alarming dyspnœa, does not as a rule require any heroic treatment. Drawing the lower jaw smartly forwards, so that the lower teeth advance beyond the upper, and withdrawal of the vapour, are, as a rule, all that the complication demands. I have met with several cases in which alarming symptoms have followed spasm of the glottis during ether inhalation. It arose, I believe, from condensed vapour impinging upon the vocal cords. Dyspnœa and violent coughing are the symptoms; the patient becomes dusky and even deeply cyanosed, and no air enters the lungs. This danger arises during the induction period, and can be usually successfully combated by traction on the tongue and oxygen inhalation. I have never been compelled to open the trachea.

If, after the upper air-ways have been cleared and rendered patent by the manœuvres mentioned above, the breathing still remains unsatisfactory, artificial respiration must at once be practised by one of the following methods.

Artificial respiration.—

1. The Schäfer Method.

Professor Schäfer,* who has investigated the relative efficiency of various methods of performing artificial respiration, finds that the following gives the fullest pulmonary ventilation and offers the best chance of ejecting fluids which have entered the lungs. The method cannot be adopted in all cases of suspended respiration under anæsthetics, since it involves placing the patient

* See *Report of Committee Roy. Med. Chir. Soc.*, 1904, vol. lxxxvii.; *Proc. Roy. Soc. Edin.*, vol. xxv., part i., p. 39.

upon his face. I quote Professor Schäfer's own words to describe the method he has suggested:—

"To effect artificial respiration, put yourself athwart or on one side of the patient's body in a kneeling posture and facing his head (see fig. 57). Place your hands flat over the lower part of the back (on the lowest ribs), one on each side, and gradually throw the weight of your body

Fig. 57. Figure showing the position to be adopted for effecting artificial respiration.

forward on to them, so as to produce firm pressure—which must not be violent—upon the patient's chest. By this means the air (and water, if there is any) is driven out of the patient's lungs. Immediately thereafter raise your body slowly, so as to remove the pressure, but leaving your hands in position. Repeat this forward and backward movement (pressure and relaxation of pressure) every four or five seconds. In other words, sway your body slowly forwards and backwards upon your arms twelve to fifteen

times a minute, without any marked pause between the movements. This course must be pursued for at least half an hour, or until the natural respirations are resumed. If they are resumed, and, as sometimes happens, again tend to fail, the process of artificial respiration must be again resorted to as before."

2. Sylvester's Method.*

For this method the patient is placed flat upon his back, with the head somewhat lower than the abdomen, and care

Fig. 58. Artificial Respiration—Expiration.

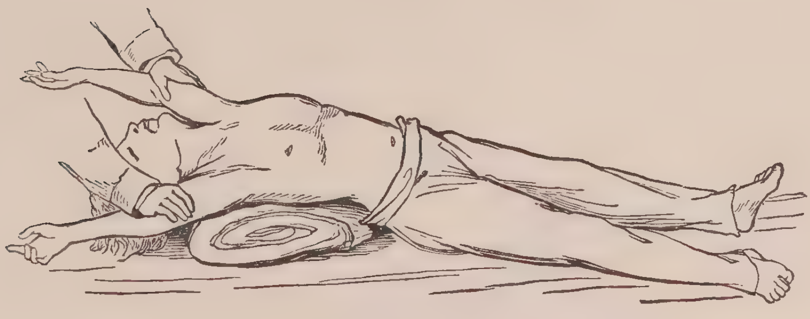


Fig. 59. Artificial Respiration—Inspiration.

taken that there is no mechanical obstruction to the entrance of air—*e.g.* falling back of the tongue, blood clot, mucus, or vomit in the pharynx.

During the performance of artificial respiration Wilson †

* The method described is modified by the introduction of the essential features of the plans proposed by Pacini and Bain.

† *Trans. of Soc. of Anæsthetists*, 1898, vol. i., p. 35.

agrees with Dr. Bowles that it is best not to have the mouth widely open, and the tongue dragged far out of the mouth.

The whole jaw should be pushed forwards, the neck being kept fully extended. There should be no strain from the chest, and so the head should not be allowed to hang back over the end of the table. The operator stands behind the patient and grasps the arms *near* the elbows in such a way as to evert them and render the pectorales majores tense. He first presses the arms into the sides, so as to compress the thorax and expel air,* whilst at the same time an assistant should make pressure upon the abdomen to prevent the increased intra-thoracic pressure from forcing down the diaphragm. Next, he firmly drags the arms away from the sides, everting them and lifting the trunk of the patient as the arms become about 45° beyond a line running through the head; finally, he carries the arms back to a line with the head. He pauses to allow air to rush freely into the lungs, and then brings the arms down to the sides as before. This process he repeats twelve or sixteen times in one minute. The way the arms are grasped is important. When they are held *below* the elbows, it is not possible to open out the chest as effectively as when the plan just described is followed.

The diagrams given above illustrate this method of inducing artificial respiration.

3. Howard's Method

can be usefully employed, in conjunction with Sylvester's. It is also of value when the patient's chest is rigid. Dr. Howard insists strongly upon the full extension of the head upon the trunk, that the air-ways may be thoroughly straightened out. The patient is between the operator's

* It is most important in chloroform cases, requiring artificial respiration, that *expiration* be performed before inspiration, in order that the chloroform-laden air in the lungs be forcibly expelled before fresh air enters.

knees. The latter, who faces him, applies his hands so as to grasp the free margin of the thorax, his thumbs resting upon the xyphoid cartilage. The patient's arms are drawn above his head. The operator presses upwards and inwards towards the diaphragm, gradually bending over the patient, so that all the weight of his body aids in compressing the thorax. After steady pressure for some seconds, with a sudden push up the operator throws himself back into his erect posture, while the resiliency of the chest walls causes inspiration. The process is repeated twelve or sixteen times a minute.

4. Marshall Hall's Method.

Dr. Bowles, whose valuable researches have made him an authority upon the subject, has pointed out that in all cases when fluid has entered the lungs this method is valuable and superior to the Sylvester method. It is performed as follows : The patient is placed upon his face, his thorax resting upon a folded pillow ; pressure is made upon his back to produce expiration ; he is then rolled on to his side ; the weight is thus taken from his ribs ; they rise, and the lungs expand—inspiration ; the trunk is then again rolled into the prone posture—expiration. This is repeated slowly about fifteen times in a minute.

Faradisation of the phrenic nerves by poles placed, one on the external border of the sterno-mastoid muscle, and one on the thoracic attachment of the diaphragm, is regarded by some authorities as of great value. Personally I consider it inferior to artificial respiration and fraught with danger.

Forced Artificial Respiration.

Professor H. C. Wood regards all the methods of artificial respiration mentioned as imperfect and inferior to

the following plan*: A pair of bellows has a length of indiarubber tubing attached to it. A face mask and two intubation tubes of different sizes are also in readiness. In the tubing "there should also be set a double tube, with an opening similar to that commonly found in the trachea cannula of the physiological laboratory, so that the operator can allow the escape of any excess of air thrown in by the bellows." Professor Wood gives the following directions for employing the apparatus: "In using this apparatus, the mask should be first tried, care being exercised to see that the tongue is well drawn forward and held in place by a thread through it, and that the epiglottis is kept open." If the face-piece does not succeed, intubation should be at once performed. In the use of either the face-piece or of intubation, the lungs should be slowly but thoroughly expanded by each stroke of the bellows. Care must be taken that only sufficient force is used to expand, not to rupture, the air-vesicles. The use of oxygen as the perflating gas greatly enhances the value of the method. The patient's body temperature should be maintained. Forced respiration is of especial value for persons with rigid chests.

All measures in artificial respiration must be adopted quietly, firmly, and slowly, since crowding, hurry, fuss, and inexpertness are very dangerous. Life may be restored after an hour's artificial respiration. The employment of the faradic current to excite the diaphragm, although formerly much insisted upon, is now generally abandoned.

Insufflation may be conducted by various methods: (1) through a tube passed through the larynx into the trachea (intubation), as in the method of forced respiration detailed above; (2) by mouth to mouth, an imper-

* See "Therapeutics," ninth edition, p. 159, foot-note.

fect plan, but one of value when no bellows are at hand, and especially so in the case of children; (3) through one nostril. Professor Schäfer tells me it is easy to perflate both lungs by means of a nasal catheter and a pair of bellows, and he regards the plan as being of great value.

II. Accidents connected with the Heart and Blood Vessels.

The most serious accidents are those connected with the circulatory system.

Faintness or **syncope** may be caused by fright before anæsthesia is established, may arise as the result of prolonged operations involving shock, or profuse hæmorrhage, or may be occasioned by the entrance of air into a vein. The gravity of the accident depends upon the various circumstances: in lesser degrees attention to posture and the maintenance of respiration will lead to the patient's recovery, while the really serious cases are hopeless, since the heart or the controlling nerve centres have been paralysed by the action of the anæsthetic.

It will be best to describe the causes of circulatory failure in detail, leaving for the moment the question of treatment. Although syncope may occur under any anæsthetic, and has been recorded as taking place under nitrous oxide, chloride of ethyl, bromide of ethyl, ether, chloroform, and the many mixtures and solutions of these agents, yet the most serious cases are those which result when chloroform is being inhaled. The symptoms hardly need recapitulation—pallor, loss of colour in the lips, ears, and finger tips, failure of pulse, dilatation of the pupils, weakening followed rapidly by cessation of the respiration. Clinically the respiratory and circulatory failure are associated. The mechanism by which this failure is brought about has

been described in the chapter dealing with chloroform; it only remains, therefore, briefly to enumerate the points which will enable the reader to recognise the bearing of the line of treatment suggested. Even a few inhalations of a strong percentage of chloroform will paralyse the heart, either by exciting vagal inhibition or by direct action upon the heart muscle (Embley and Martin; Sherrington and Sowton). When respiration is interfered with, through whatever cause, the heart's action is hampered, the nervous control is seriously threatened, and even small quantities of chloroform may lead to serious or even fatal complications. Under any percentage of chloroform the blood-pressure falls. Its fall is gradual so long as respiration is unaffected and no intercurrent complication such as hæmorrhage occurs. In prolonged operations, especially if the anæsthetic has been given at all freely, this fall of blood-pressure becomes more serious, and syncope may supervene. When pallor and weakening of the respiration appear, the head should be lowered, and more air or oxygen should be given. A sudden fall of blood-pressure may occur quite early in narcosis, especially in young delicate children. It seems to be due, either to their inhaling an unduly strong percentage, or to the onset of vomiting. Even if the last cause is the occasion of the pallor, it is unwise to push the anæsthetic, as children in this condition are easily poisoned. In combating the dangers of the fall of blood-pressure, it is most important to bear in mind the condition of the patient's organs at the time of the inhalation. If, for example, the heart is fatty and its action feeble, if the respiration is hampered by old-standing lung disease or pulmonary œdema, the risk of even a slight fall of blood-pressure is enhanced, and it is necessary to restrict the percentage of chloroform. The most dangerous period of narcosis, as far as the circulation is concerned, is the

induction. Struggling at once hampers respiration, interferes with the action of the heart, and leads to an irregular intake of chloroform. Holding the breath produces like results.

Treatment.—This necessarily varies, according as the patient is suffering from a slight fall of blood-pressure, or has inhaled an overdose of the anæsthetic. The patient should at once be placed supine, the legs and arms raised, and the head dropped below the level of the trunk, partial or complete inversion being of the greatest value in syncope during narcosis; smelling salts or ammonia fumes should be applied to the nostrils, and the præcordium rubbed with a warm hand. In faintness inhaling nitrite of amyl is useful. The maintenance of regular respiration is of the greatest importance in all cases of syncopal seizure, and to this end artificial respiration must be practised at once. Rubbing the inside of the lips with brandy is of marked value in these cases. An enema of brandy—℥ss. in ℥ij. of hot beef-tea or gruel or starch—may be tried. When the patient has recovered sufficiently to swallow, hot strong coffee with a teaspoonful of cognac should be given. The most stringent injunctions must be given that the horizontal posture be maintained until the heart has quite recovered itself.

In graver cases.—Bandaging the abdomen is certainly valuable, and should be adopted when the blood-pressure has fallen through vaso-motor paresis. Rectal injections of hot water or saline are of undoubted utility.

The treatment rehearsed above also applies to these cases; in them it is usually more common to find a *gradual heart failure* occurring, and giving warning of trouble. Respiration also is liable to flag at the same time as the heart fails. It is especially necessary, therefore, to have resort to artificial respiration early, both on this account and be-

cause that measure even by itself will frequently steady the heart and restore its rhythm. Maas's method of rapid percussion over the cardiac area has been already noticed. In all syncopal attacks, while the above measures are being adopted, an assistant should dash cold water over the face and chest, and fillip the latter with a towel end, wrung out in ice-cold water. Hypodermic injections of either spartein (gr. $\frac{1}{2}$) or oxyspartein (Langlois and Maurange) are of service in averting heart failure under chloroform. Transfusion of normal saline has been used successfully in cases of syncope associated with severe hæmorrhage under anæsthetics. The saline solution may be introduced directly into a vein, or infiltrated through a cannula into the cutaneous tissues of the thigh or arm.

Acupuncture of the heart.*—In a series of careful experiments Dr. B. A. Watson has shown the utility of puncturing the right ventricle in cases of heart failure under chloroform. It is possible by this plan to remove the excess of blood from the overtaxed heart at the same time that a mechanical stimulus is applied to the myocardium. The plan has been tried in the case of human beings, but I believe without conspicuous success.

Direct Massage of the Heart.

The heart muscle may not respond to puncture, but it is well known that, when subjected to direct manual manipulation, it is capable of expelling its contents and resuming its normal rhythm. Guided by this physiological fact, Prus † has suggested a plan by which the surgeon can gain access to the heart, in cases of cardioparesis under anæsthetics, and excite it to renewed activity. He suggests

* See a useful paper by Dr. B. A. Watson, *Trans. of Amer. Surg. Assn.*, May 13, 1887.

† *Hospitalstidente,* 4 Roekke, Band viii., No. 47, R. Kier-Peterson.

the following method: An oblique incision is made through skin and muscles, and a flap formed with its base to the left mammary line, and its borders parallel to the third and fifth ribs and left sternal edge. The third and fourth ribs are cut close to the sternum, and two and a half inches are resected in the flap. Access to the heart in the pericardium is thus obtained, and it can readily be compressed between the fingers. Weber * points out that Prus's incisions are dangerous, and suggests as an alternative: From the right edge of the sternum, close to the insertion of the fourth rib cartilage, an elliptical flap of skin and muscles is made across the sternum to the upper border of the corresponding rib on the left, about a finger's breadth from the sternum. This is continued obliquely over the fourth, fifth, sixth, and seventh ribs, ending at the left costal margin. The sternum is sawn across at the level of the skin incision. The intercostales in the third space are carefully detached, care being taken to avoid injuring the internal mammary artery, and the cartilages of the fourth to the seventh ribs are cut from without inwards. The xyphoid cartilage is divided with bone forceps and the flap dissected up. Less severe measures than those described above have been adopted in several cases. The abdominal parietes are divided and the heart is grasped from below either indirectly, *i.e.* with the diaphragm intervening, or, directly, through an incision in the diaphragm. In most instances, as in the case reported by Dr. Starling and Mr. Lane,† the operation being an abdominal section, there is no delay in thus gaining access to the heart. Even when this has not been the case, surgeons have preferred to open the abdomen and approach the pericardium from below, a course which appears to involve less risk. Professor Keen, who has collected a

* *Centralbl. f. Chir.*, 1899, Band xxvii.
† *Trans. Soc. Anæsth.*, vol. vi., p. xxvii.

number of cases, has shown that up to the present time, although the procedure described has delayed the fatal issue, it has done little more. Dr. Starling's patient survived, but then the anæsthetic used was ether, and so the heart was presumably not acutely dilated. If adopted early in the course of resuscitative attempts, direct rhythmic compression of the heart alone, or coupled with acupuncture and withdrawal of blood, would seem to offer more hope of success than other procedures.

Accidents occurring in the Post-Anæsthetic Stage.—These may arise as the result of faulty position, collapse from shock, and chilling of the body when the patient is carried from a hot operating-room into a fireless bedroom.

Faintness and vomiting are dangerous if the patient is allowed to be placed in bed with the head higher than the body, or in such a position that he can roll upon his face. There should be always an attendant to turn the head (it is not necessary to raise it) when vomiting occurs, to prevent vomit being aspirated into the air-passages.

Collapse is best treated by heat applied to the patient's body, great care being taken that the hot-water bottles do not cause burns. When morphine has been given immediately before the operation or at its close, and before the anæsthetic stage has passed off, there is a danger of the development of deepening coma, enfeeblement of respiration, and circulatory depression.

Many have observed that in some cases patients, who were apparently suffering but slightly from shock and in a light degree of narcosis at the close of a prolonged operation, became progressively more collapsed and profoundly unconscious within a short time. Their breathing became feeble, the pulse weak, and the skin cold—these symptoms may arise from surgical shock, but are as a rule due to

unnecessary quantities of the anæsthetic having been inhaled and the incautious use of morphine after chloroform. The treatment is that mentioned in dealing with "shock."

Occasionally patients, after ether, become maniacal, and require control.

Paralysis following Anæsthesia.—Both central and peripheral paralysis may follow anæsthesia. The central form is due to rupture or blocking of blood-vessels, the result of alterations of blood-pressure caused by anæsthetics. Thus **apoplexy**—a rare accident—has been recorded. Beyond attention to the posture of the patient, little can be done in such cases. The choice of the anæsthetic and method of administration should be guided by the necessity for avoiding struggling and an increase of blood-pressure, and to ensure absolute freedom from asphyxial complication. These ends are best attained by using chloroform with oxygen from a Vernon Harcourt inhaler. Erb and others have pointed out that peripheral paralyses follow the use of anæsthetics and are usually due to traumatism from pressure on nerves—for example, when the arm is allowed to hang over the side of the operating table and the musculo-spiral nerve is compressed. Even the forcible extension of the arms upward may injure the brachial plexus. Functional paralysis also may follow anæsthesia. In all the above cases care in avoiding pressure upon nerves is the important matter: after-treatment may be carried out on general principles.

Glycosuria: Diabetic Coma.—Diabetics must always run an increased risk in taking an anæsthetic. The amount of sugar should be lessened by rest and treatment before the inhalation, and chloroform should be selected and exhibited with oxygen from a regulating inhaler, and every effort made to limit the amount given.

CHAPTER XI.

LOCAL ANALGESIA—SPINAL ANÆSTHESIA.

Local analgesia, that is, loss of sensation to painful stimuli without the superinduction of unconsciousness, is obtained in the following ways.

(1) By drugs painted over or injected at the situation desired to be rendered insensitive. Those most usually employedare Cocaine and its salts; Eucaine β; Tropacocaine; Holocaine; Stovaine; and Novocaine. (2) Injections into the spinal canal (spinal anæsthesia). (3) Injections into the sheath of nerve trunks (neural anæsthesia). (4) By cold. (5) By electricity.

Cocaine ($C_{17}H_{21}NO_4$). Gardeke, in 1855, had isolated the active principle of the leaves of the Cuca plant which he called erythroxyline, but Niemann, who adopted cocaine as the name of the alkaloid, made the first investigations of its action. In 1884 Karl Koller introduced the use of cocaine into surgery.

Cocaine forms salts with acids. These are readily soluble in water. The alkaloid has a bitter taste; forms crystals; is with difficulty soluble in water (1 in 700 or more). Its solubility is greater in alcohol (1 in 20), in chloroform or ether; in melted vaseline, and castor oil, cocaine is freely soluble. Pure cocaine, or the hydrochlorate, gives no coloration, or a very faint evanescent yellow one, with concentrated cold sulphuric acid. It may readily be recognised by its crystals, which are colourless monoclinic prisms. Cocaine readily undergoes chemical changes in its composi-

tion, so that solutions for use should be made fresh as required. Its anæsthetic properties are destroyed by boiling.

Maclagan has suggested the following test of purity. He dissolves 1 gr. of the hydrochloride in 2 ounces of water, and drops in 3 minims of the B.P. solution of ammonia. Upon stirring with a glass rod, a crystalline precipitate is thrown down while the mixture remains free from turbidity.

Cocaine acts as a general anæsthetic when very large doses are taken. Its true action is analgesic, due not to the vasomotor constriction which it establishes, but to its influence upon the sensory nerve endings. If an area is rendered anæmic and analgesic by cocaine, the subsequent injection of pilocarpine will abrogate the anæmia, while the analgesia remains unaffected. Arloing has shown the same thing by dividing the sympathetic of a rabbit on one side, the animal having been previously cocainised, hypervascularity could thus be seen to exist simultaneously with analgesia.

Physiological Action of Cocaine.

In **cold-blooded** animals cocaine, whether applied to the heart itself, circulated through the detached ventricle, or injected into the circulation, slows the rhythm, and depresses the beat, and finally arrests the heart in diastole. Its depressant action upon the heart is shown by the accompanying cardiogram (taken by the author with Roy's tonometer) (fig. 60).

Cocaine also interferes with cardiac innervation, decreasing in a very marked degree the excitability, for while it abolishes "make" contractions, "break" contractions persist. Although both auricles and ventricles are influenced, the latter are more interfered with, and cease to beat before auricular rhythm is arrested (Van Anrep).

The blood-vessels are but little, if at all, affected by cocaine, unless it be applied locally as a paint, and in this case, it is doubtful how far the action is really characteristic of the drug.

In **warm-blooded** animals, an initial increase in rapidity of the heart's beat occurs, the heart's action is weakened, but usually recovers and is said to survive the cessation of respiration (Van Anrep). Vagal inhibition is also much depressed and even lost; blood-pressure is greatly lowered, although this is preceded by an initial and transient increase of pressure.

Cocaine produces a very marked **depressing action** upon the **human heart.** Many persons, after even small doses, become pallid and complain of extreme faintness, while the heart's action grows weak and irregular, the radial pulse becoming almost indistinguishable. Cocaine in very large doses (and we must remember that what constitutes a large dose varies greatly among different individuals) renders the respirations more rapid, irregular and shallow, and finally asphyxiates by respiratory paralysis. In human beings, marked dyspnœa and breathlessness may follow its use.

Convulsions and epileptiform seizures, due, it is said (Durdufi), to vasomotor irritation producing anæmia of the brain, occur after toxic doses. Death, according to Mosso, results from tetanic contraction of the diaphragm.

The nervous system is much affected by cocaine. The peripheral nerves of sense become anæsthetic over the area into which cocaine has been injected, the analgesia extending just so far as the drug traverses the tissues. When injected into a nerve trunk, it blocks the transmission of impulses, and thus lessens shock (Crile). The results are obtained, although with less certainty, by injections made into the tissues surrounding nerve trunks.

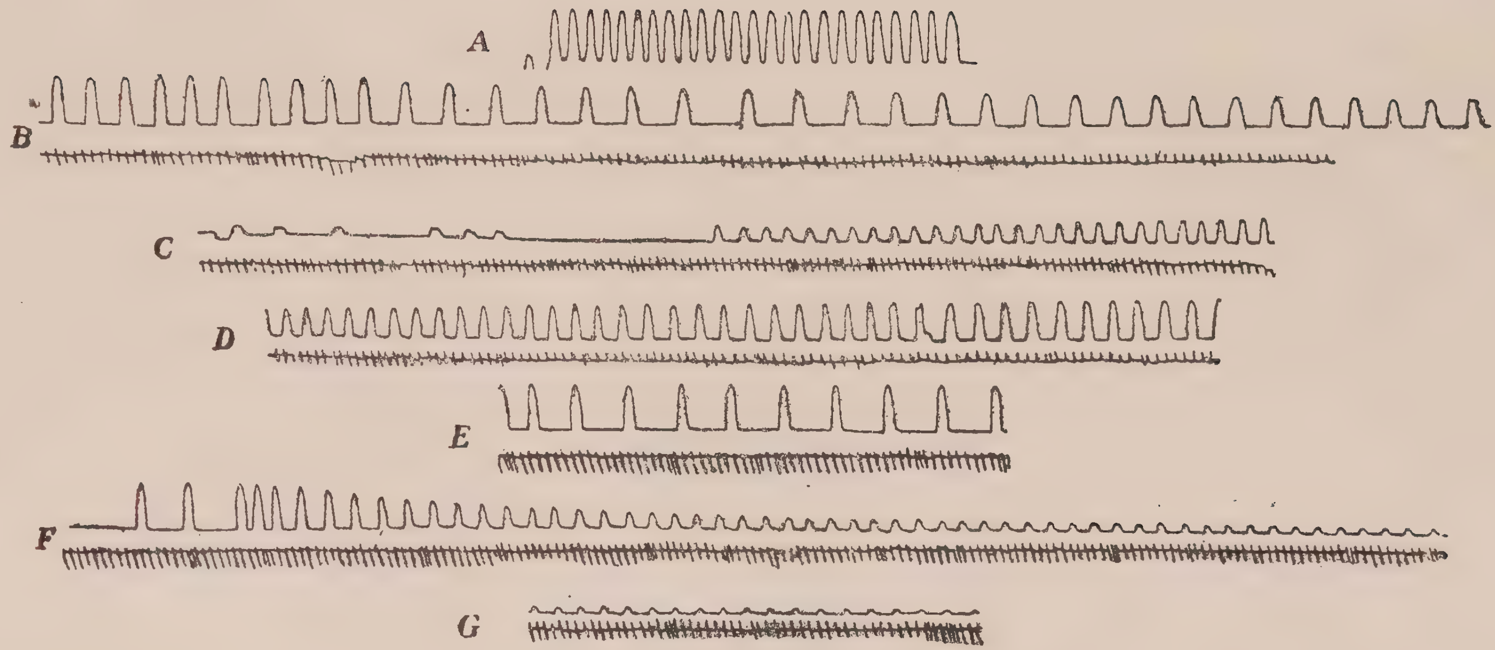


FIG. 60. –Cardiograms of frog's heart (effect of cocaine). A. Normal trace. B. After addition of cocaine. C. Cocaine removed, nutrient fluid recirculated. D., E. Recovery to normal. F. Cocaine again circulated. G. Extreme heart failure, no recovery.*– Taken with a Roy's Tonometer.

The insensibility wears off in time, and is followed by more or less severe "reactionary pain" (Struthers). When injected into the subarachnoid space anæsthesia of the lower extremities is produced, but is often associated with severe cephalalgia, and sometimes fatal results. Dastre very aptly terms cocaine the "curare" of the sense nerves. Painting over the skin or mucous membranes produces a result similar to what occurs after hypodermic injection, but in a less degree, and due to absorption. The motor nerves are usually only affected by large doses, but in some persons, comparatively small doses have induced paresis or paralysis, lasting for hours or even days. Ptyalism occurs, leading to dryness of the mouth and fauces. Peristalsis is increased and vomiting and borborygmi follow its use. The other secretions of the alimentary tract are lessened. The urea and phosphoric acid excretion is increased by it (Fleischer). Cocaine promotes destruction of tissue and by a constant repetition of this process leads finally to physiological ruin. Mydriasis and proptosis, in warm-blooded animals, follow its use. Cocaine causes also great hyperexcitation of the muscular system and marked agitation; a large dose at first may simulate strychnine in its action, by producing muscular tremblings, convulsive movements, and spasms.

Although the mind at first remains clear, there is usually a tendency to garrulity, followed by great anxiety and feelings of unaccountable distress. Languor, muscular weakness, and lassitude will then take possession of the patient, who becomes haunted by most fantastic hallucinations. Some persons simply experience slight elation, or it may be drowsiness, but loquacity is the most usual symptom.

Cocaine would appear to produce an hyperexcitability of the spinal cord, evincing itself in muscular tremblings

and twitchings (Dastre) ; a similar condition of the medulla accounts for the vasomotor and respiratory disturbance, while an increased excitability in the cortex brings about convulsions (Richet). In fine, the effect on the nervous system may be summed up in the words of Dastre, who says that while the drug paralyses the terminations of the sensory nerves, it excites initially all other parts—nerve trunks, spinal cord, medulla, encephalon, and the sympathetic chain.

Cocaine produces at first a slight rise in body temperature. It is eliminated by the kidneys, and often produces albuminuria, or glycosuria, which Van Anrep regards to be the result of the partial paralysis of respiration.

No attempt has been made to describe at all fully the symptoms which characterise poisoning by cocaine. These are bizarre to a degree, and may be grouped as (1) more or less heart failure with a remarkable lowering of blood-pressure, paling of the skin and mucous membranes; (2) great dyspnœic distress from failure of respiration; (3) impairment of mental faculties and even unconsciousness, or in some cases catalepsy. Convulsions may occur, or a loss of movement in various groups of muscles. While such symptoms usually occur only after the injection of a considerable dose of cocaine, they may follow the use of even a small quantity. Retention of urine, protracted insomnia, and prolonged anorexia are also recorded (Kümmer). Perhaps the most serious danger of cocaine is its liability to induce a drug habit. Those who have had cocaine injected or even applied to mucous membranes, experience a feeling of pleasant exhilaration, and soon learn to repeat the application in order to renew the sensations. The habit once formed is hardly broken. Cocaine mania rapidly destroys mental and physical sanity, and premature death results.

METHODS OF EMPLOYMENT.

1. Instillation into the eye.
2. Painting over mucous surfaces.
3. Subcutaneous injections.
4. Infiltration (Schleich and Reclus' methods).
5. Spinal anæsthesia.
6. Neural anæsthesia.

Whatever method be adopted, it should be remembered that a **dose** of one grain will in a large number of persons produce unpleasant, if not dangerous, symptoms, half a grain is a safer dose, though even this may in many people give rise to trouble.

1. **In ophthalmic practice** a few drops of a 4 per cent. solution are instilled into the conjunctiva; this is repeated two or three times at brief intervals, and then five to ten minutes are allowed to elapse before operating. If the manipulation takes long, it will be necessary to repeat the process from time to time. Another and useful method of administration suitable for eye work is the placing of an easily soluble cocaine tablet in the oculo-facial fold of the conjunctiva.

2. For **cutaneous and mucous surfaces.**—As a paint, 20 per cent. solution is used, weaker preparations being of little value over cutaneous surfaces. Several coats are necessary, and even then, as a rule, anæsthesia will not extend much deeper than the true skin.

When employed for mucous surfaces, especially if there be any possibility that some of the solution may be swallowed, a dilution of 5 per cent. should be adopted. In laryngoscopic and rhinological examination some recommend a 20 per cent. solution, painting the naso-pharynx with it. When strong solutions are employed, great care must be taken to mop away all excess.

Cocaine is also employed as a spray in an atomiser, a 4 per cent. solution being used.

In rhinological examinations, etc., a dossil of wool soaked in a 5 per cent. solution is placed in the nares until sensation is lost.

3. **Hypodermic injection.**—Most marked effects, both local and constitutional, follow the use of cocaine when injected hypodermically. Employed in this way, its action is more rapid and more persistent than when applied as a paint or an ointment. A 10 or 20 per cent. solution is usually employed, and from 2 to 5 minims injected at the site of operation. As the effect may pass off before surgical interference has been completed, it will often be necessary to inject a second or third dose during the operation. Great care must be taken to avoid the injection entering a vein, as it is probable that many of the deaths following the use of cocaine have resulted from this accident. From five to ten minutes must be allowed to elapse after injection before the knife is inserted. Injection of cocaine into the tissues is now seldom practised, except when the infiltration method is employed, and even then eucaine β is employed in preference to cocaine. The advantages of eucaine β are that it is far less toxic and can be readily sterilised by heating.

Dose.—When highly diluted solutions are employed, experience shows that a larger dose is borne without toxic effects being manifested. One to one-and-a-half grains in a one per cent. solution is stated by Reclus to be a safe limit, and double this dose when a half per cent. solution is employed. However, this is a large dose and is seldom now employed. The addition of adrenalin (*vide* infra) renders large doses safer.

4. Infiltration Method.

Schleich * of Berlin, Reclus † of Paris, and Oberst of Halle have practised methods of local anæsthesia by the endermic and hypodermic injections of greatly diluted solutions of various anæsthetic substances. Drs. Braun and Heinz have systematised and simplified Schleich's procedure, and in the following account of the infiltration method their directions are mainly followed. Braun has revolutionised the methods of producing local analgesia by the introduction of his plan, in which solutions of adrenalin and cocaine or eucaine β are employed. Not only is the analgesic effect produced, but the part is rendered ischæmic and toxic dangers are diminished.

Schleich's solutions are three in number:

	No. 1.	No. 2.	No. 3.
Cocaine Hydrochlor. . .	0·2	0·1	0·01
Morphin. Hydrochl. . .	0·025	0·025	0·005
Sodium Chlorid. . .	0·2	0·2	0·2
Aq. destill. sterilisat. ad. .	100·0	100·0	100·0

These solutions are employed according as a deep, medium, or evanescent anæsthesia is desired. A preferable solution is one composed of eucaine β one part in a thousand of saline solution (sodium chloride eight parts) by weight (Braun and Heinz). The eucaine β is not decomposed by boiling, and so can be completely sterilised.

Adrenalin.—The modern practice is to combine this drug with cocaine or eucaine. A solution of 1 in 200,000 adrenalin chloride is employed. Excessive doses (15 drops of a 1 in 1,000, is given as a maximum by Struthers) produce faintness and respiratory difficulty. The following is the method recommended by Braun.

* "Schmerzlose Operationen," Berlin, 1899. In this exhaustive work all Schleich's earlier work is focussed.

† *Rev. de Chirurgie*, p. 158, Paris, 1899. See also *La Cocaine en Chirurgie*, Paris, 1895.

Technique.—The syringe is constructed to hold 10 c.c., see fig. 61. The piston must be absolutely true, and all the junctions must fit accurately, otherwise the resistance offered by the tissues injected causes the solution to leak back above the asbestos piston. Braun's syringes are made so that they can be readily taken to pieces, boiled, and put together again.

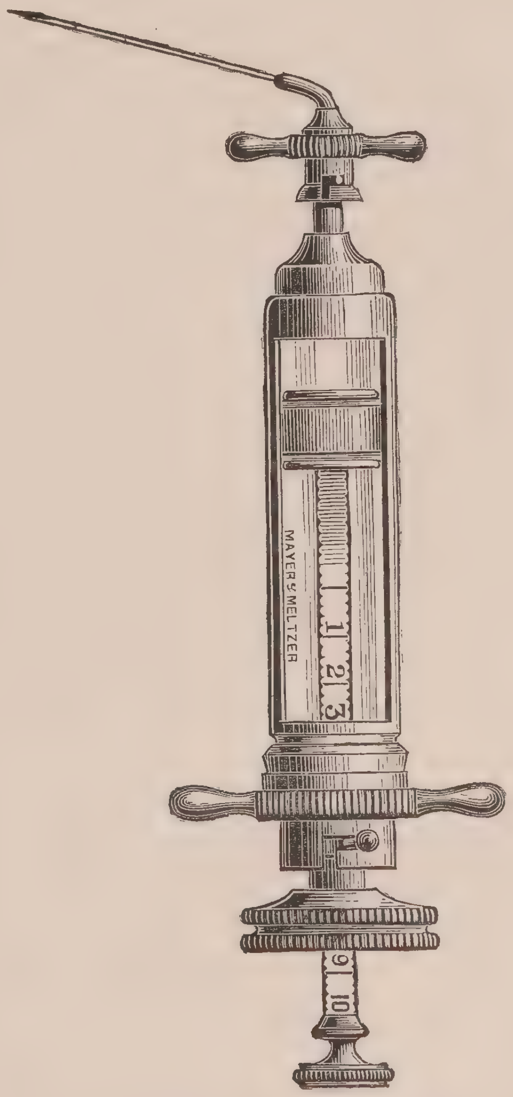


Fig. 61.—Syringe for use in local analgesia.

The solutions and syringe having been carefully sterilised and the skin thoroughly cleansed, the needle is inserted *endermically* and some solution injected. The wheal resulting is again injected at its periphery, and this is injected in like manner until a linear zone of skin is rendered œdematous by the fluid introduced. Subsequent injections are made hypodermically and when the deeper structures are to be operated upon these are also injected. It is advisable to wait for some twenty minutes, or longer, between the time of injection and the performance of the operation.

When the structures are cut, much of the œdema fluid flows away, but the tissues remain analgesic for some twenty minutes. Repeated injections are made as the operation is in progress. Large quantities of the solution may be employed. It is usual to scheme the line of injections in such a way that all skin areas which are to be cut are made analgesic. The nerves supplying them, and the deeper structures also, are rendered incapable of transmitting painful impressions by injections made into the tissues surrounding them. The anatomy of the particular region must be studied in the case of all regional operations, and the injections made accordingly. In the present chapter it is impossible to enter into further detail.

Precautions.—Nervous patients are not good subjects, as they complain, are restless, and sometimes get faint and vomit. The most extreme care must be taken to insure asepsis in the tissues and instruments. It is extremely difficult to make inflammatory areas analgesic, and they, as well as those invaded by morbid growths, are liable to the danger of having the *materies morbi* injected into healthy areas during the infiltration. All loose tissues, such as those about the tongue, must never be infiltrated, as death, due to œdema glottidis from escape of the injected solution, has resulted when the attempt has been made. It is practically impossible, by this method, to render the hollow viscera, *e.g.*, stomach, analgesic. I have seen great shock occur when the viscera were handled during an operation under the infiltration method, even though the viscus had been carefully irrigated with the eucaine solution. It is difficult to estimate the amount of pain suffered by the patients who are infiltrated. Some appear to have little or none, some more than they can bear. Vomiting and faintness, with much pallor,

sometimes occur. Children are usually too frightened to submit to the process and are upset by it. Some experience in the technique of the injection is needed to get a fairly good result, and the operator, unless accustomed to the altered appearance of the tissues caused by the infiltration œdema, will often be at a loss to distinguish structures as he meets with them in the course of his dissections. As a rule picking up bleeding vessels causes pain. It is recommended that patients should take a meal before the operation and be given alcohol, as it is said that it lessens the sensibility of the tissues. For fuller details the reader is referred to the exhaustive work of Braun * and papers by Braun, Heinz, and Barker.†

Dr. Leonard Corning of New York, proposes yet another method of using cocaine. He first marks out with crayon the superficial veins, to obviate a possibility of puncturing them, and next exsanguinates the limb with an elastic bandage and Esmarch's cord. He then injects superficially 3 to 5 drops of a 1 or 2 per cent. solution of cocaine hydrochlorate immediately above the cord. After waiting until the skin is anæsthetic, he injects the deeper tissues with a solution of the same strength, making twenty or more punctures according to the area to be rendered insensitive. Dr. Corning then appplies a tourniquet at the upper limit of the anæsthetic zone, and after a few minutes operates.

This method assumes that cocaine is able to permeate the tissues slowly and exert its paralysing action upon the peripheral nerve endings instead of being absorbed rapidly into the circulation. Oberst has pur-

* "Experimentelle Untersuchungen und erfahrungen über Infiltrationsanästhesie," in *Archiv f. Patholog., Anat. und Physiol.*, von R. Virchow, Berlin, Bd. 153, Hft. 3, p. 466. Die Localananästhesie, von Dr. med. H. Braun, Leipzig, 1905.

† *Lancet*, Feb. 1899, and July 1903: *Jour. Brit. Med. Assn.*, Dec. 24, 1904.

sued this plan clinically, and it is usually called by his name.

From the account given of its physiological action, it will be evident that the injection of cocaine is not free from risk, and that special dangers arise in various operations. Thus panophthalmitis has followed its use for eye operations. Instillation is not sufficient for extirpation of the ocular globe, or for tenotomy; for these operations subconjunctival injection is necessary. In many cases patients complain that the division of the deeper structures causes much pain in spite of cocaine. The presence of glaucoma is a contra-indication to the employment of cocaine; indeed, according to Javal, its constant use may induce a glaucomatous condition.

Although advocated when foreign bodies have to be removed from the cornea, cocaine possesses a serious drawback, inasmuch as it induces flaccidity of the eyeball, and so seriously impedes the operative measures.

In general surgery.—The infiltration method has now been employed very largely, and especially in Germany, France, and the United States. Nearly every kind of operation has been undertaken during its use with varying success. While many have restricted its employment to cases in which a general anæsthetic is contra-indicated, others have adopted it as a routine plan. Cocaine and even eucaine β have not proved uniformly safe, and stovaine (*vide* infra) has as yet received too limited a trial to warrant its unrestricted use.

The technique introduced by Braun undoubtedly has lessened the percentage of failures and diminished the frequency and severity of dangerous sequelæ. When, however, one compares the results of a large number of local anæsthesia cases with a corresponding number of cases in which a general anæsthetic has been given with

equal skill and precaution, there seems to be far less to recommend the local method than at first sight appears. The effect upon the nerves of many patients of being conscious during the operation is undoubtedly very bad.

The method, moreover, is not suitable for all operations—*e.g. excision of the tongue* has been attempted, but without uniform success, and, as has been pointed out above, there is great danger of œdema of the glottis being caused when the infiltration is made into the loose tissues about the base of the tongue.

Operations on the urino-generative tract.—The injection of a few drops of a 2 per cent. solution into the urethra is said to render catheterisation painless, but this is only true when no stricture exists. In like manner the operations of lithotrity and litholapaxy may, it is said, be undertaken after an injection of cocaine (5 per cent.). Grave dangers have followed the incautious use of cocaine in this department of surgery, so even when local analgesia is feasible it is doubtful whether the patient does not run an even greater danger from its use than that to which a general anæsthetic may expose him.

In Dental Surgery.

For the adjustment of clamps and separators, the introduction of wedges, the application of ligatures for the rubber, for excavating, filling, trimming, or polishing deep cervical edges of cavities, the removal of tartar in pyorrhœa alveolaris, the modelling of sensitive and irritable mucous membranes, cocaine as a paint of a 10 per cent. strength is used, or a spray of 2 or 4 per cent. according to the degree of sensibility manifested by the parts. Cocaine is used before lancing and excising gum-tissue, and for the relief of pain after extraction, though it is usually

inadequate to accomplish the latter. For anæsthetising pulps before extirpation cocaine is also used.

Cocaine is not satisfactory for tooth extractions; small doses are inadequate, and larger ones too frequently give rise to constitutional derangement, which is often alarming. As a rule, a grain is needed to anæsthetise sufficiently to permit of extraction, and ten minutes must be allowed to elapse before applying the forceps. It is best to inject by three punctures, one on the lingual, and two on the labial aspect of the tooth. One of these being before, and one behind the prominent ridge on the buccal alveolus, they will correspond to the roots of the tooth to be extracted. An enlarged experience has practically settled the question whether cocaine can be safely used in dental operations, and has shown that the method is both dangerous and unsatisfactory. Few now employ it, and all those who have had much experience have met with cases which have caused great alarm and in which the patient's life was endangered.

Preparations used for Local Analgesia.

A few words may be added upon this subject. Cocaine and eucaine β have been most extensively used, but, as has been indicated, both possess disadvantages. Cocaine is not easily rendered sterile, and is liable to produce constitutional symptoms, while eucaine β is less potent, and not so easily diffused. Stovaine is weaker than cocaine; its solutions are acid and easily precipitated by weak alkalies, and its injection, it is stated, has caused gangrene. Alypin, which has been vaunted as free from these defects, is more soluble, but Braun found its solutions caused some irritation, damage to tissues; and in 5 per cent. concentration gangrene has followed its injection. Both alypin and

novocaine (see below) have been employed for spinal injection. Novocaine is said to cause no irritation, and as large a dose as 4 grn. has caused no toxic effects when injected into the tissues. Scopolamine appears to be too weak when used alone for local analgesia, and to combine local injection with the use of a general anæsthetic seems an unnecessary complication of methods unless there is a very cogent reason for minimising the dose of the general agent employed. In such a case the choice of a more powerful local analgesia is probably indicated.

5. Spinal Anæsthesia.

Although Corning in 1885 suggested injections into the subarachnoid space, Bier * was the first to attempt systematically the production of anæsthesia for surgical purposes by injecting drugs into the spinal canal in the region of the lumbar cord. Bier employed cocaine. Extensive experience, however, convinced him, as it did others who adopted his suggestion, that the method was too dangerous for general application.

The introduction of Braun's system of combining adrenalin with cocaine, although it lessened the dangers frequently associated with the method, yet failed to obviate them in all cases. Among other drugs, stovaine has proved least toxic, and is at the present time most generally used. Even stovaine has been found by Preindlsberger † to be unsatisfactory, and after using it extensively, he returned to tropacocaine. The fatalities and untoward sequelæ following spinal injection have been attributed to the toxicity of the drugs

* "Versuche über Cocainisirung des Rückenmarkes," von Prof. Dr. August Bier. *Deutsche Zeitschrift f. Chirurgie*, Bd. 51, Sept., 1899. See also *Münchener medizinische Wochenschrift*, 1905, no. 23, p. 1117.

† *Allgemeine medizinische Zentralzeitung*, 1905, no. 42, p. 808.

cocaine and its congeners, and also to the injection of the water or normal saline employed in the solution of the drug. To avoid these sources of danger, the cerebrospinal fluid withdrawn from the subarachnoid space has been employed as a solvent for the stovaine, or whatever drug is to be introduced. The possible infection of the spinal canal must be reckoned with, and avoided by aseptic methods.

Method.—The patient should be warned of the possible failure of the plan, of its sequelæ, and of the reasons for employing the method in place of a general anæsthetic. It is better to keep him without food for the four hours antecedent to the operation, as, if the spinal injection fails, a general anæsthetic may be required. The skin of the lumbar region is carefully prepared, and all sources of infection removed. The instruments and solutions must be rendered sterile, as disaster follows the slightest want of care in effecting sterilisation. Stovaine can be boiled, but cocaine cannot be dealt with in this way. Two postures have been suggested, the sitting, and the reclining. Of these the former is the better when the patient is able to adopt it, as more space is obtained for the introduction of the needle. The patient sits upon the table in what is called the "scorcher" attitude (Halstead), the back flexed and the head well down towards the thighs. If the patient cannot assume this position, he is made to lie on his side upon the table, and his spine is strongly flexed.

The iliac crests are then made out with the finger, and a line taken across the back from their highest points. This gives the position of the fourth lumbar spine, and with this as a guide, the spines of the higher vertebræ can be readily found.

The point selected for puncture varies; some prefer the interspace between the third and fourth lumbar spines, and some that between the second and third. Authorities differ,

also, as to whether the puncture should be made, as shown in the frontispiece, a little to one side of the middle line, in a direction upwards, forwards, and inwards towards the median line, so as to pierce the dura in the middle line; or whether it should be made directly in the middle line. The contention that the former plan gives more space is contested by Dönitz,* who strongly advises the median puncture. The higher injection is recommended by Tuffier and others, when it is desired to anæsthetise the upper part of the body. The instruments required are a glass syringe fitted with an absolutely true piston, a fine trocar, and cannula, capable of being pushed from 2 to 4 inches into the back. The seat of puncture may be rendered analgesic with ethylchloride spray, or the patient given morphine half an hour before the operation. Schleich's plan of infiltrating down to the seat of puncture is hardly necessary, as, if the cannula and needle are properly bevelled, little pain is experienced. The puncture is rendered easier if the skin is divided with a tenotome, but even this is rarely necessary. The needle is introduced at the point and in the direction selected; care being taken to traverse the space between the two spines, either in the median line, and so as not to strike the bone; or on one side of the tip of the spine upwards, forwards, and towards the central line of the body. The depth to which the needle has to penetrate varies from 2 to $3\frac{1}{2}$ or even 4 inches. The resistance at first experienced is suddenly diminished as the needle pierces the ligamenta subflava; the needle is then pushed on slowly until cerebrospinal fluid, at first tinged with blood, drops from the cannula. If no fluid follows the puncture, even when the cannula is pressed well in and gently moved, or if the flow is not in a rapidly dropping stream, it will be necessary to withdraw

* *Arch. f. Klinische Chirurgie*, 1905, Bd. 77, Heft 4.

the cannula and make a second puncture. When, however, the flow is satisfactory, the solution to be injected is mixed with cerebrospinal fluid, 1 to $1\frac{1}{2}$ c.cm. being slowly injected.* It is advisable to withdraw a little cerebrospinal fluid into the syringe and reinject this after the first injection to ensure that any of the solution which remained in the syringe may in this way be made to enter the subarachnoid space. The patient is placed upon his back after the puncture hole is covered with collodion, and he should remain undisturbed for ten to fifteen minutes. When the upper part of the pelvic region is to be operated on the pelvis is supported upon a pillow to allow the injection to gravitate upwards, but this is an unsafe procedure when cocaine or tropacocaine is injected, as in that case faintness, nausea, and other unpleasant symptoms are likely to be produced. The solutions employed are: stovaine 4 per cent. solution gr. $\frac{1}{2}$ to gr. $1\frac{1}{6}$ may be employed with a few drops of 1 in 1,000 solution of adrenal active principle; tropacocaine up to gr. $1\frac{1}{6}$, although as much as $2\frac{1}{2}$ gr. have been used; cocaine 2 per cent. solution 10 to 15 minims, with a few drops of 1 to 1,000 solution of adrenal principle.

Another drug, novocaine, has recently been tried (Hofmeier), and, it is stated, has proved more satisfactory than stovaine. Novocaine was discovered by Einhorn, and has been experimented with by Biederfeld, Braun, and others. It acts more upon the sensory and less upon the motor nerves than stovaine, and is in this respect superior to that preparation. Meltzer has obtained some success with solutions of sulphate of magnesia; while alypin, another recent addition to the pharmacologists' armamentarium, has received encomium from those who have employed it.

* Billon of Paris supplies capsules containing 2 c.cm. of solution of stovaine, with adrenalin of a strength of ·04 grm. stovaine to the c.cm. Of this 1 c.cm. is the usual dose, but allowance must of course be made for the capacity of the needle.

These preparations are at present under trial, and it is premature as yet to give a definite opinion upon their merits.

Dangers and After Effects.

Young children and nervous persons are unsuitable subjects for spinal analgesia. "Aseptic" meningitis, convulsions, epileptiform seizures, fever, severe often stunning headache, nausea, faintness, respiratory distress, and persistent paraplegia have been met with, and it is stated that the spinal cord in some instances has become permanently affected. These dangers are far less common when stovaine is used. Failure to enter the canal and inability to establish anæsthesia, even after injection, are not infrequent. When cocaine is employed the spread upward of its effect is an ever-present danger and must be carefully guarded against by making the area of injection the lowest part of the body. The most usual sequelæ are the splitting headache, inability to sleep, nausea, vomiting, cramping pains in the abdomen, circulatory disturbance, and profound mental depression. Kocher is inclined to think the tissues heal less readily, but Halstead has not found this to be so. It sometimes happens that the injecting needle becomes entangled in the nerves and the fluid does not enter the subdural space. Hemianæsthesia is a further cause of failure. This is due, as shown by Dönitz, to the failure of the needle to enter the space lying below the cord and between the two bundles of nerve roots. This emphasises the importance of puncturing exactly in the middle line.

Treatment on general lines should be pursued, and needs no detailed reference in this place.

Summing up the arguments in favour of spinal analgesia, those who have employed the method fail to show that it is safer than chloroform, or more free from unpleasant

sequelæ. Hare regards it as only applicable to cases for which general anæsthesia is an impossibility. It may be pointed out that the use of regulating apparatus for giving chloroform has reduced the dangers to a minimum, so that it seems hardly justifiable to employ a method, the safety of which is not by any means established, in the place of one the dangers of which may be accurately estimated and are extremely small when entrusted to competent hands.

6. Neural or Regional Anæsthesia.

Injections into nerve trunks (Crile) render the regions supplied analgesic. Corning, some years ago, showed that perineural injections sufficed to produce analgesia in the region supplied by the nerve or nerves injected, and Oberst has systematised and brought the plan into practice. It is satisfactory, but can only be relied upon in a small number of operations upon the fingers and toes. To carry out either of these plans it is necessary to infiltrate the tissues in the region of the nerves or plexus to be dealt with, search for and then inject the nerves. Crile relies upon a 0·5 per cent. or 1 per cent. cocaine solution for the intra-neural injections, but the effects soon pass off. Braun, by employing adrenalin with cocaine and trusting to perineural injections appears to have obtained better results, and avoids the tedious dissections often involved when a number of nerves have been sought for and injected.

Local Analgesics.

Eucaine β resembles cocaine in its general behaviour. It is less toxic, and its action upon the heart is less depressant. It is a vasodilator, and diffuses less readily than cocaine. The hydrochlorate and lactate of eucaine are both in use, the latter being the more soluble.

In infiltration analgesia the following formula (Hare) is

recommended : Beta-eucaine, gr. i. ; common salt, gr. x.; aq. dest. ℥iij. It is better, however, to add adrenalin as described above. Its solution may be boiled before use.

Poisoning by eucaine presents symptoms similar to those of overdosage by cocaine. Dose 1·5 to 2 grains, if used in a 0·5 per cent. solution, but double this amount may be used with a 0·1 per cent.

Tropacocaine has been used in ophthalmic and dental surgery (gr. ivss. to gr. vi. in extractions). Its action was carefully worked out by Chadbourne of Boston.* Custer † recommends it as a suitable substitute in infiltration fluids. It has been extensively tried for intraspinal injection, gr. i. to gr. ij. being employed ; the dry powder may be dissolved in cerebrospinal fluid (H. Koder).‡ Others prefer Bier's method as safer.

Stovaine. A body of very complex chemical composition. Was first made by Fourneau. It occurs in small white lustrous scales and is acid to litmus. The employment of this drug for local and intraspinal analgesia has been introduced by Pouchet, Tuffier, and employed largely abroad, and has been used in this country by Barker. It is a synthetic product, produced from tertiary amylic alcohol, being in fact the hydrochlorate of amylene. Its use in local anæsthesia is less reliable than that of other drugs, but the experience which has been gained shows that it is less dangerous, and in many cases quite satisfactory in spinal anæsthesia. It is less powerful than eucaine. It is used in 0·5 per cent. or 1 per cent. solutions, the maximum dose being 2 grains. It has been extensively used for intraspinal injection. A 10 per cent. solution is used, the maximum dose being 0·5 to 1·15 grains. Bier combines stovaine with adrenalin.

* See *Brit. Med. Journ.*, 1892, No. 1651, p. 402.

† "Cocain und Infiltrationsanästhesie." Basel, 1898. In this book much valuable information on the method of infiltration will be found.

‡ *Wiener medicin. Wochense*, 1905, no. 37, p. 1781.

Holocaine has been successfully employed by Deneffe of Ghent, Gutmann in Germany, and Brudenell Carter in England. In ophthalmic practice 1 per cent. is used.

Acoïne, according to Darier,* is of equal value in ophthalmic surgery to the above, and has been substituted by Trolldenier for cocaine in his infiltration solutions. Brudenell Carter speaks highly of acoïne. Both holocaine and acoïne have been employed in local anæsthesia.

Novocaine is colourless, soluble in water, unaffected by boiling, less toxic than stovaine, and is said to be non-irritating to the tissues. Braun has used 0·25 to 2 per cent.

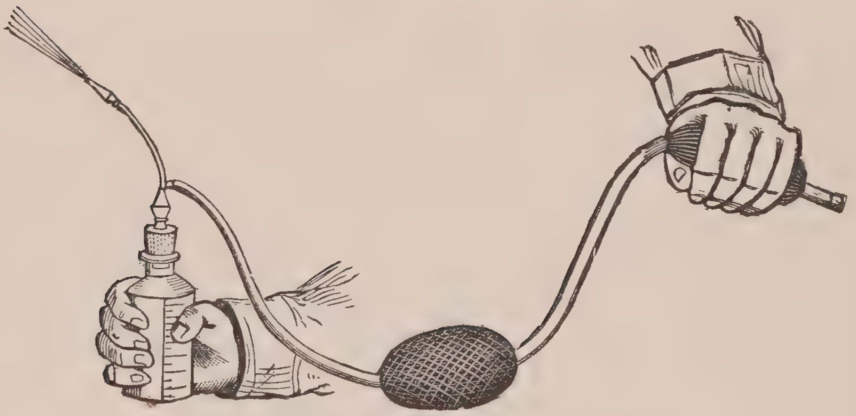


FIG. 62. Ether spray.

for local injections with suprarenal extract. For intraspinal injection the following solution is recommended : Novocaine, 0·2 gm. ; suprarenal extr. (1 in 1000), 5 m. ; sod. chlorid., 0·018 gm.

Ether spray † (Sir B. W. Richardson).—The woodcut explains the simple mechanism of this contrivance.

The anæsthesia so obtained is confined to the skin, and is very transient. Recovery of sensation when the spray ceases to work is often accompanied by very painful smarting and

* *La Clinique Ophthalmologique*, June 25th, 1899, p. 134.

† Richardson recommended anhydrous ether, sp. gr. 0·720, mixed with an equal part of hydride of amyl (Rhigolene).

tingling. The great drawback to the method is that the instruments and skin get thickly coated with ice, which obscures the parts, rendering the use of the knife almost impossible. Further, under ether spray it is difficult to see and secure blood-vessels, and painful to do this when the anæsthesia has passed off. Unless care be taken, the skin may be so much frozen that a slough like that of frost-bite will follow.

Various agents have been employed which produce a certain degree of analgesia by freezing the tissues upon which they are sprayed. We may mention **Chloride of methyl and Chloride of ethyl.**

Coryl.—A name given by G. Joubert to chloride of ethyl mixed with chloride of methyl so as to lower its boiling point from 10° C. to 0° C.

Anesthyle is the name given by Dr. Bengué to a mixture of 1 part chloride of methyl to 5 chloride of ethyl. Its use is similiar to that of coryl.

Rhigolene, a product of the distillation of petroleum, was introduced by Richardson, who employed it instead of ether in his atomising spray.

These substances are kept in tubes with specially constructed stop-cocks, which allow of spraying over the area to be frozen.

A large number of drugs have been proposed as local anæsthetics, but as few have special advantages no further mention need be made of them here.

Faradic currents directed for some minutes through an area of skin or mucous membrane produce some degree of analgesia. At one time this method was in vogue among dentists; it has now fallen into disuse. A recent attempt has been made to revive this plan, an improved apparatus being employed, but the success achieved seems to have been so slight as to make it hardly necessary to particularise its features.

CHAPTER XII.

MEDICO-LEGAL ASPECTS OF THE ADMINISTRATION OF ANÆSTHETICS.

The administration of an anæsthetic to a patient who is not a minor, against his will, constitutes an assault. When a patient has voluntarily submitted himself to be anæsthetised he may, under the influence of terror, during an early stage of the proceedings, attempt to prevent further narcosis; he is then not sufficiently guided by his reason, and the administrator is bound, in the patient's interest, to take his own course.

The anæsthetist, like any other medical man, is liable to prosecution for malpraxis; it then rests with him to prove that whatever steps he took were adopted after due consideration and because he believed them to be the best he could follow in the interests of his patient. Such questions as the following might arise: Did the anæsthetist undertake a duty which knowledge, skill, and experience had qualified him to fulfil? Did he employ the most suitable agent according to his view of the exigencies of the case? and did he administer it with due skill and by the most approved method? Did he possess himself of all necessary facts with regard to the patient's bodily condition? and did he make due allowance for these in the treatment which he pursued? In the event of an accident of any kind, did he adopt the right and appropriate treatment indicated in such an emergency? and was this done with due promptitude?

Anæsthetics have been employed to assist in the

perpetration of **various crimes** upon the person narcotised. Thus, it is alleged, an anæsthetic may be given without the consent of a person; or, when given with his or her consent to effect a lawful procedure, advantage may be taken of the anæsthetised person's helpless condition to perpetrate a crime.

Can an anæsthetic be administered without **consent?** Firstly, can this be done whilst a person is awake and in full possession of his senses? Formerly many cases came into the law courts, in which the complainant alleged that a handkerchief saturated with chloroform was waved before his face and unconsciousness followed *immediately*. This we now know to be an impossibility; a period of time varying from two to twelve or more minutes must elapse before an individual passes under the influence of chloroform, and during this time fresh supplies of the anæsthetic are needed. Further, chloroform in most cases, produces so much excitement, that one person would find it a difficult matter to keep the victim sufficiently still to complete the anæsthesia, and would hardly do so without much noise and disarrangement of the victim's clothing. Further, unless food is avoided before the anæsthetic is given, vomiting is very liable to occur, and with it a return to consciousness.

It is often alleged by the supposed victim that he, or she, was conscious of what was being done, but was powerless alike to speak or resist. Such statements must be received with the utmost caution. It is true that Péan recorded cases in which patients, though rendered analgesic by ether, retained their consciousness as to what was in course of proceeding. Cases like Péan's must be so exceptional that one is tempted to believe the anæsthetic was administered very imperfectly, and that faith in the assurance of the surgeon did the rest. Snow also admits the possibility

of persons imperfectly chloroformed being conscious and yet powerless to resist. In attempts at criminal violence under an anæsthetic administered without the victim's consent, fear, excitement, and struggles would all be against the possibility of arriving at loss of voluntary power without deep narcosis. It is very doubtful whether a person, be he an expert or not, could narcotise a waking adult against his will unless there existed a very unusual disproportion between the strength of the two individuals. In the case of R. *v.* Snarey the prosecutrix alleged that she had been rendered insensible instantly by something being held over her face upon a handkerchief, and that in that condition she had been violated. This contention could not, in the present state of knowledge, be admitted by experts. However, in a parallel case, that of White *v.* Howarth, the prosecutrix made a similar assertion, and added that she was aware of what was going on but was unable to resist.

Although the time required to thoroughly anæsthetise a patient is longer when chloroform is used than when ether is employed, yet, from the highly irritating nature of the vapour, ether is less easy to administer to an unwilling patient than is chloroform. And further, ether requires the use of some apparatus entirely excluding air, and is hence less easy to manipulate by those who are not experts. In general it may be affirmed that, if it is difficult to use chloroform for criminal purposes, the employment of ether presents greater difficulty. In a case reported, it was alleged that a burglary was carried out by men who chloroformed the owner of the property as he lay in bed and then ransacked the premises. The presumption must always be against the truth of such statements. Persons left to guard banks and other places containing valuables have on several occasions affirmed that they were rendered

unconscious by chloroform while a robbery was carried out. It is inevitable, in such cases, to doubt the truth of the story, and indeed the persons uttering it have in some instances been shown to have been the actual depredators.

Can a Person be Anæsthetised during Sleep?

Dolbeau made careful experiments with reference to this subject, and his conclusions are certainly consonant with the experience of most skilled anæsthetists.

He first attempted to anæsthetise four persons during sleep. Three were awakened in the process. In his second series of cases four persons out of six awakened, and in his third series only three persons awakened out of nine to whom he administered chloroform while they slept. Dr. Turnbull asserts that either chloroform or ether may be given without awakening the subject of the experiment. I have no doubt that chloroform may in some cases be so administered, but am less sure about ether; in either case certain conditions must be present to ensure success. The greatest care, skill, and familiarity with the anæsthetic used might enable an expert to succeed, and then probably only in the case of a heavy sleeper. Dr. Leonard Guthrie repeatedly tried to chloroform children in their sleep, but he never succeeded.

A further question arises, upon which evidence may be sought, and that is whether, in the event of his escaping capture, it is possible to prove the person attempting to administer an anæsthetic with criminal intent was one skilled in its use. To determine this offers some difficulties. The presence of apparatus, the method in which lint or a handkerchief is folded, or blistering of the lips and nose from allowing the chloroform to drop upon the face, might offer a clue. If ether be employed we may be sure that

the person using it possessed some knowledge, especially if he had used an apparatus; since ether given by the open method seldom if ever carries the patient beyond a stage of delirious excitement, producing bellicose struggles such as would effectually prevent the accomplishment of any criminal design.

Anæsthetics have been given to assist in the committal of ROBBERY, RAPE, and MUTILATION. What has been said above leaves little to add with regard to robbery. Cases have occurred of persons who, it was alleged, were rendered irresponsible for their actions for some weeks, or longer, after taking an anæsthetic. Such instances of temporary insanity are very rare, but may arise among the neurotic, and those whose family history reveals a tendency to mental instability.

In a case in which the writer was asked to give expert evidence, a highly respectable young man was charged with indecent exposure. The defence, which was accepted by the judge as conclusive, was based upon the fact that the defendant's mental poise had been upset as a result of inhaling an anæsthetic. The family history was one of marked mental infirmity.

Attempted Rape under Anæsthetics.

Many cases have now been reported in which the prosecutrix has affirmed that a dentist or medical man has violated her person while she was under the influence of an anæsthetic. So frequent are such charges that the greatest care should be taken in order to ensure the presence of a third person at least within ear-shot and preferably within sight of the administration of the anæsthetic. No administrator of an anæsthetic is safe from having such a charge preferred against him, and if

he and his supposed victim are alone it is simply a case of word against word. Further, the woman may be *enceinte* at the time of the alleged rape, and may subsequently give birth to an infant whose parentage she may find it convenient to fasten upon the medical man.

But it is not only designing bad women who bring such charges: modest, virtuous, and refined gentlewomen have been the accusers in these cases. The cause for this remarkable and deplorable state of things is fortunately not far to seek. Chloroform, ether, possibly also the other carbon compounds employed in producing anæsthesia, nitrous oxide gas, and even cocaine, possess the property of exciting sexual emotions, and in many cases produce erotic hallucinations. It is undoubted that in certain persons sexual orgasm may occur during the induction of anæsthesia. Women, especially when suffering from ovarian or uterine irritation, are prone to such hallucination, and it is almost impossible to convince them, after their recovery to consciousness, that the subjective sexual sensation had no objective origin. It is stated that women at their menstrual periods are more prone to erotic hallucinations than at other times, a fact which may be borne in mind. A case cited by Sir B. W. Richardson will illustrate this statement. A young lady had chloroform administered to her by a doctor in the presence of a dentist and the young lady's mother and father. After the tooth had been extracted, and the patient became conscious, she steadfastly affirmed that she had been criminally assaulted by the dentist, and to this statement she adhered, although the four persons present in the room strove to disabuse her mind.

In considering the evidence is such cases, the following points need especial attention :—

Nature of the anæsthetic.—Chloroform, ether, and the other members of the carbon anæsthetic series, certainly

render persons wholly unable to protect themselves from any personal ill-usage. The body of the anæsthetised patient is, however, rendered utterly flaccid, and is a dead weight. If then there is any question of moving the body—as, for example, from a dental chair, and again back into the chair—it must be remembered that such an undertaking would be exceedingly difficult for one individual, however strong, and could hardly be accomplished without causing much disarrangement of clothing.

On the other hand, if the offence was alleged to have been committed when the patient was under the influence of nitrous oxide gas, it would have to be borne in mind that the effect of this gas is to produce, first muscular rigidity and subsequently violent jactitation. Further, unconsciousness only persists for about half a minute, or, in exceptional cases, a trifle longer, and the patient regains her senses with control over her muscles in a few seconds. This being so, it is exceedingly improbable that even a premeditated and skilfully planned attempt at violation would be successful if made upon a woman under nitrous oxide gas.

A caution is needed about admitting the evidence of a person only just recovered from an anæsthetic. The following case illustrates this: A dentist appealed to a friend to extract a tooth. Under gas he struggled so violently that the operation was not attempted, but, as he came to, he reproached his friend most bitterly, telling him he had felt the whole pain of the extraction and was even then suffering torture.

Death under an Anæsthetic.

It becomes requisite to decide whether the death was suicidal, accidental, or due to an anæsthetic given by a second person; and then whether that individual was competent to

administer it. Chloroform is frequently used as an anodyne, and many deaths have resulted from accidents, such as the soaking of the patient's pillow with chloroform. The presence of a phial near the corpse might point to self-administration. Ether is not used similarly, and is not selected by suicides. One death from nitrous oxide gas, under similar circumstances, is reported from America. A dentist, whilst under the influence of drink, placed himself in his chair and, turning on the gas, held the face-piece over his mouth and nose. In the morning he was found dead, and the gasometer empty. A somewhat similar case occurred in England.

It is important to carefully search for evidence as to *how* the anæsthetic was administered, as this may determine whether it was done *secundum artem* or unskilfully.

The **inquiry** into a **death** supposed to be from an **anæsthetic** commences with the question—Was it due to the anæsthetic, to hæmorrhage, shock, exhaustion, or to some other complication following the surgical operation? The mode of death due to chloroform, ether, and other agents, is described under the heading *chloroform*, etc.

The CHOICE of the ANÆSTHETIC would have to be JUSTIFIED: thus, were chloroform given for a simple tooth extraction in lieu of the safer agent—nitrous oxide gas—and were the patient to succumb, the administrator would have to explain why he selected the most dangerous agent and what physical conditions existed which justified him in his choice.

All anæsthetics are dangerous. In the hands of one skilled in their use this danger is minimised; but, whatever may be individual uses and opinions, the general consensus of belief places anæsthetics in the following order of safety: nitrous oxide gas when used for short operations; ether; chloride of ethyl; chloroform. Other substances are

not used sufficiently often to make statistics reliable, but the following table gives a rough estimate of their danger.*

TABLE SHOWING DEATH-RATE UNDER THE VARIOUS ANÆSTHETIC BODIES.†

	Deaths.	Administrations.
Chloroform (Coles, Virginia) .	53	152,260
,, (Richardson) . .	1	2,500 to 3,000
,, Baudens (during Crimean War) . . .	1	10,000
,, War of Secession .	1	11,448
,, Gurlt (Reports in Germany, 1895 and 1896)	29	34,401
,, Julliard (Geneva) .	161	524,507
Ether (Andrews ‡) . . .	1	23,204
,, Julliard (Geneva) . .	1	14,987
,, Lee (Chicago) . .	4	92,816
,, Gurlt (German Hospitals, 1895 and 1896) . .	3	13,008
Nitrous Oxide Gas . . .	1	100,100
Chloride of Ethyl . . .	1	13,000
Amylene	2	238
Hydrobromic Ether . . .	2	600
A.C.E. mixture, No. not ascertainable §		
Methylene mixture . . .	1	5,000

* No great stress can be laid upon such figures, as in many cases a death occurred very early in the career of an anæsthetic, and this rendered further trials of it nadvisable.

† The Report of Anæsthetics Committee, Brit. Med. Assn., July 1900, gives 18 chloroform deaths in 13,393. These are classified as 3 due wholly to chloroform, 4 principally to it and 11 doubtful. Under ether 6 deaths in 4,595 cases, but none entirely due to the anæsthetic.

‡ Probably too low an estimate.

§ Richardson states erroneously that no death has occurred under A.C.E. mixture. Dr. Reeve of Dayton, Ohio, reports three deaths, and several others have been recorded.

It must be added that Scotland presents a series of statistics much more favourable to chloroform; thus, out of 36,500 administrations at the Edinburgh Infirmary during ten years, only one death has been recorded. Inquiries recently made have revealed that several deaths from chloroform have occurred at the various surgical centres of Scotland, so that the above estimate can no longer be taken as a reliable statement of the death-rate from chloroform.*

Dr. McEwen gives his own results at Glasgow (computed, not recorded) as 11,886 cases of anæsthetics, 500 of which were ether cases. He makes various deductions from his total and regards 10,000 with one death as his chloroform record. Sir George Macleod mentions 15,000 cases with one death, and Dr. Buchanan 9,000 with one death. This gives the total of 34,000 with three deaths, or one in 11,000 about, for three leading Scotch surgeons. This estimate cannot be taken as representing accurately the death-rate under chloroform in Scotland at the present time.

Questions of Responsibility.

These arise when the patient dies under an anæsthetic, and may involve the question as to whether the most suitable anæsthetic was employed by the best method. Sometimes a patient refuses one anæsthetic, preferring another; here the administrator clearly cannot shirk responsibility, but must give that agent which he deems best if actual danger is involved in deferring to the wish of the patient. In the converse case, when death occurs during the administration of an anæsthetic which the patient declined to take until persuaded, cajoled, or forced into so doing, the

* No Coroner's Inquest is held in Scotland upon "Deaths under Chloroform," hence their occurrence does not obtain publicity.

anæsthetist would have to show that his special knowledge guided him in making his selection, which, although it led to a fatal result, was, in point of fact, the best choice he could make in the patient's interests. In the employment of a new or untried anæsthetic, very grave responsibility would rest with the administrator unless he very fully and clearly explained the possible results, and obtained the patient's consent to the trial.

A question which we have not yet considered arises—Who, in the eye of the law, is qualified to administer an anæsthetic? At present some uncertainty exists upon the point, owing to discretionary power being left to the operator to assume the so-called responsibility of the anæsthetic. Thus nurses, students, butlers, coachmen, dispensers, and various unqualified persons have been frequently permitted to give the anæsthetic, or, as the phrase is, "keep it going," while the surgeon, besides operating, is supposed to exercise a general supervision over the administrator's proceedings. If any accident happened the certificate would have to be signed by the surgeon, and the Coroner's Court might admit the principal's evidence. It cannot be doubted that, to give any individual an anæsthetic subjecting him to a minimum of danger is all one person can do, and can only be accomplished by those specially instructed and experienced in the use of anæsthetics. Were an action for damages raised upon a death occurring under the above-named circumstances, there is little doubt that the persons proceeded against would be heavily mulcted, since nothing short of the utmost emergency could justify the proceeding.

The more stringent view now taken by the General Medical Council with respect to "covering" renders the position of a qualified medical man who allows an unqualified person to assist him by administering an anæsthetic a

difficult one. Unless it could be shown that the aid of a second qualified medical practitioner could not be obtained or that delay was detrimental to the patient, the question of "covering" would arise, and might be difficult to meet.

Recently an action for malpraxis was taken out in a colonial court against a medical man who had administered chloroform to a patient with a fatal result. The question rested upon whether the anæsthetic was rightly and skilfully given, and this being taken as proved, the court decided the case in the medical man's favour.

In another case the medical man administered the anæsthetic (chloroform) without assistance, and proceeded to operate. The patient, however, died, and an action for damages was brought and eventually decided in the medical man's favour. The line of defence adopted was (1) the medical man was duly qualified; (2) chloroform was necessary; (3) the operation being slight—moving a joint—the presence of a second doctor was unnecessary; (4) all was done which experience and knowledge demanded; (5) the death was unavoidable, and not due to carelessness or want of skill. Expert witnesses were called for the defence to show that the anæsthetic used was a suitable one, and that it was properly administered.

Should Dentists give Anæsthetics?

How far dentists practising with or without the L.D.S. diploma are legally justified in administering anæsthetics is a moot point. Many hold that the L.D.S. confers a right to the administration of nitrous oxide gas, but no other form of anæsthetic. In the United Kingdom no trial case, I believe, has been contested. The ground for this affirmation that licentiates in dental surgery possess such a right has no legal basis, but has grown out of the belief that the use of nitrous oxide gas is part and parcel of the dentist's

calling, and that so he has a right to employ it. This, however, applies with equal force to all registered dental practitioners. Probably the issue would rest, in the present ambiguous state of the law, more upon the experience and recognised skill of the person administering the anæsthetic than upon the nature of his qualification. Thus, could it be shown that a registered practitioner, after two or three thousand successful administrations, met with an accident, in spite of all due care and precaution, he would probably be in a better position than would a well-qualified practitioner, who met with a fatality presumably through maladroitness, if it were shown that he had never obtained a practical experience in giving anæsthetics.

In any case, a person would be open to grave censure, if not liable for malpraxis, were he to undertake the administration of an anæsthetic, and operate single-handed, unless it could be shown that to do so was a necessity, no help being available.

Legal Responsibilities of Anæsthetists.

It has been made a subject of much debate—with whom rests the responsibility of the choice of the anæsthetic, the surgeon who operates, or the anæsthetist who gives the anæsthetic? Clearly this must depend entirely upon the understanding which exists between the two. If the anæsthetist is called in, as an expert, to decide what anæsthetic is best for any given patient, his must be the sole responsibility; while if he is present simply as an assistant to the surgeon to give in the best possible way an anæsthetic which is named by the latter, his responsibility can extend only so far as the actual administration is concerned. If the two disagree, the surgeon, insisting upon an anæsthetic which the anæsthetist conscientiously believes will jeopardise the patient's

life, cannot cover the anæsthetist, and the latter has but one course to adopt, namely, to retire from the case. As, however, the experience of the surgeon may equal or exceed that of the anæsthetist, especially if the patient is the former's, to retire from the case is a grave step for any anæsthetist to adopt, and could only be justified in most extreme cases. It is best, in all cases of doubt, that a consultation between the surgeon and the anæsthetist be held and the questions of choice of anæsthetic and method be discussed deliberately from the two points of view.

Covering.

It has been decided by the General Medical Council that any medical man who gives anæsthetics for a dentist who does not in fact possess the right to practise as a dentist, is in the eyes of the Council guilty of the offence of "covering." No pronouncement has, I believe, been made dealing with the question of a duly qualified medical man giving an anæsthetic for a non-qualified person, or one who is not registered, in order to assist him in the performance of any operation or an examination. It is probable that a case of this kind would also be regarded as an act of "covering," and would carry with it the punishment accorded to that offence. The kindred case of a qualified medical man inviting an unqualified assistant to give an anæsthetic has frequently arisen. As has been pointed out above, unless it can be shown that the help of a second qnalified practitioner could not be obtained, the qualified practitioner might be liable to an indictment for "covering."

Anæsthetics for Illegal Operations.

How far, in the eyes of the law, an anæsthetist would be regarded as an accomplice to the operator is at present undetermined by judicial decisions. In the event of the

anæsthetist becoming acquainted with the nature of the proposed operation before the anæsthetic was given, he would certainly be incriminated if he then assisted the carrying out of the operation by administering the anæsthetic. Whilst it is not the business of the anæsthetist to inquire into the nature of any operation, or to criticise the way in which it is performed, he should make himself acquainted with the fullest details of the case if he has his suspicions aroused. When any doubt is present in his mind as to the legality of the operation, or as to the bona fides of the person conducting the case, he will do wisely to retire from it, as his presence gives his tacit consent to the operation and would probably place him in the same position as the operator should legal prosecution follow. It need hardly be pointed out that the anæsthetist shares in no way the legal responsibility, as to the advisability of an operation, the manner in which it is performed, its success or failure, save and except in so far as these may be involved in the manner in which he has conducted the administration of the anæsthetic. An exception to this arises when the anæsthetist becomes acquainted beforehand with any facts which make it evident that the operation is a fraud or undertaken to obtain money by false pretences, and is not one which would be performed by any recognised authorities upon the subject. Under such circumstances the anæsthetist has but one course open to him, viz., to retire from the case.

Death from Nitrous Oxide Gas.

The deaths which have occurred when the patient had inhaled or was inhaling this gas, cannot be imputed to any specific action it exercised. In some cases heart failure occurred upon the patient's resuming consciousness *before the operation was completed*, and in others respiration was inter-

fered with by gags slipping and setting up laryngeal spasm. Unquestionably there is danger if the patient is allowed to feel pain, especially in operations upon the fifth pair of nerves; but little, if any, when the gas is given fully and the operator warned to desist before consciousness returns. In one case an elderly lady died under this anæsthetic. She was wearing extremely tight corsets, her heart was diseased, and her stomach contained food. The gas was, moreover, administered twice. It has been stated * that when nitrous oxide and oxygen are given together acute dilatation of the heart takes place and fatal results follow if chloroform is given after this mixture.

The P.M. appearances are simply those of death from syncope, or of death from asphyxia.

Death from Ether.

Ether, when swallowed, gives the following symptoms. The patient is lethargic or comatose, breathing slowly, deeply, and with stertor, the skin is pale and cold, and covered with clammy sweat. The exposed mucous membranes will be purplish; the face livid; the pulse quick, soft, small and compressible. Complete muscular relaxation gives the body a flaccid, doughy feel. The eye is fixed and glassy, and usually smeared with a thick film of mucus, the pupil is dilated and insensitive to light. The body temperature is depressed several degrees below normal.

If the vapour of ether has been inhaled, a much smaller dose suffices to produce death than when liquid ether is swallowed. The symptoms detailed above may be brought on in from three to five minutes. Six drachms to an ounce are necessary to produce narcotism when swallowed.

* *Proc. Soc. Anæsth.*, vol. ii., p. 179.

The symptoms and appearances of persons dying as a result of ether inhalation will differ according as the ether has caused respiratory or circulatory failure. In cases of acute pulmonary œdema the lung symptoms will predominate, while cerebral hæmorrhage occurring under ether will give the characteristic symptoms associated with the brain lesion.

Post-mortem appearances.—If examined within twenty-four hours after death, the brain, lungs, liver, spleen, or kidneys, upon being cut, give a strong ethereal smell. The blood is dark and thick, although still fluid. The lungs are congested posteriorly and filled with aërated spumous fluid in front (Taylor). The bronchial mucous membrane is reddened from injection throughout its entire extent. The cerebral and spinal vessels are found congested, and the meninges stained.

Ether, when swallowed, has not caused death in the human subject (Taylor). Orfila, experimenting upon dogs, found the mucous membrane of the stomach of a black-red colour, acutely inflamed by a lethal dose of ether. The duodenum was also red and inflamed, and the heart contained black blood which was partly coagulated.

The detection of ether by analysis.—Ether in liquid may be distilled from the stomach contents and led through a glass tube containing asbestos moistened by a mixture of sulphuric acid and saturated solution of bichromate of potash. The asbestos turns green.

Its odour is also characteristic; ether burns with a smoky yellow flame; it is only slightly soluble in water.

The tissues.—In recent examinations the odour is characteristic. Since but little ether is absorbed by the blood, and of this little some is converted into aldehyde (Taylor), it is almost impossible to separate ether by distillation from it or the solid tissues.

Death from Poisoning by Chloroform

May occur through inhaling the vapour or drinking the fluid. If examined before death the individual will be comatose, breathing stertorously, with slow, shallow, respirations. The skin will be cold and blanched, the face livid, the lips ashen in hue, the pulse imperceptible, and the pupils may be widely dilated, but insensitive to light. Muscular flaccidity is present, bnt epileptiform convulsions often occur.

Post-mortem appearances.—In cases of death from chloroform the appearances reported vary very much, and this is probably due to the confusion present in the minds of many persons concerning the connexion of cause and effect. Thus death from asphyxia, fear, shock, and so on, may be attributed to chloroform; furthermore, the autopsies are seldom made soon enough to be of any value, while sufficient note is seldom taken of the degree of narcosis in which death occurred. We should expect the cadaveric appearances presented in the first degree to differ widely from those found in later degrees, and yet in but few records have I been able to find any information bearing directly upon this point.

In the earlier degrees chloroform congests the vessels of the brain and cord, and so this condition, although inconstant, is sometimes found.

The lungs are usually deeply congested, the heart empty, flaccid, or containing a little fluid blood. In some cases the right heart is full, even to distension, of dark fluid blood (asphyxia). The blood remains fluid, it is very dark, and is said occasionally to contain bubbles of gas (Taylor). Snow, analysing thirty-four cases, describes visceral engorgement, but in some instances he found the lungs normal. Casper denies that any of the features pictured above are patho-

gnomonic of chloroform poisoning. When the drug is swallowed it produces gastro-enteritis, and pathological appearances resulting from this would be seen post-mortem. The appearances of the viscera in "delayed" chloroform poisoning (acidosis), as in the case of delayed ether poisoning, are not characteristic. The liver is often small, friable, and atrophic and the gastro-intestinal tract is congested.

Detection of chloroform.—The odour very soon passes off. Dr. Taylor failed to detect any in the blood half an hour after administration. Analysis of the blood also fails to reveal any evidence after half an hour.

Analysis of the tissues.—The substance supposed to contain chloroform is placed in a flask, one end of which is in a hot-water bath, the other communicating with a tubulure which is heated by a flame. The bath is raised to 160°, while the tube is heated to redness. Chloroform vapour driven off by the heat of the water bath is split up as it traverses the tube, hydrochloric acid and chlorine being set free. The vapour reddens blue litmus, precipitates solutions of nitrate of silver, and liberates iodine from iodide of potassium, which is tested in the usual way—with starch paper. The most accurate method of obtaining a quantitative analysis is that of Vernon Harcourt.

Self-Indulgence in Anæsthetics.

A "habit" has been unhappily created for most forms of anæsthetics. Thus, some persons become addicted to self-administration of chloroform; others to that of ether; others again to that of chloral, while cocaine also has its victims. It is not within the scope of the present work to describe the proper modes of treating the slaves of such unfortunate habits, but merely to draw attention to them,

that medico-legal questions arising out of such depraved practices may receive due notice. Nitrous oxide gas, although presenting greater difficulties to self-administration, has yet led some weak-principled persons to practise self-induction of anæsthesia by its aid.

The possibility of the subject of an inquiry—in any case of supposed suicide or murder by anæsthetics—being an habitué of one of them, should not be allowed to drop out of mind.

Insanity following the Administration of Anæsthetics.

Among persons predisposed to insanity the administration of anæsthetics may, in certain rare cases, determine an attack of mania. "It is the fact of the temporary disturbance of function, and not the means by which this is produced, which is of most importance" (Savage). It is stated, upon the high authority of Dr. Savage, that chloroform, ether, nitrous oxide gas, or indeed any anæsthetic, is capable of so interfering with brain functions, that the delirium of commencing narcosis may become reproduced upon the patient's recovering from the sway of the anæsthetic, and may either persist as intractable mania, or pass off after expending its violence in a sharp but transient maniacal seizure. This liability was also noted in 1865 by various speakers at the meeting of the Superintendents of American Institutions for the Insane, at least as far as chloroform and ether were concerned. The possibility of such a result ensuing upon the administration of an anæsthetic to a person either highly neurotic, or coming from a family in which insanity has been developed, should be borne in mind when such individuals are examined with a view to ascertain their fitness for anæsthetisation. The

suggestion that such persons should be treated with spinal or local analgesia cannot be considered satisfactory. Mania is recognised as a possible result of these methods, and those who have had much experience warn us against employing them for neurotic and nervous patients.

INDEX

DD

A. C. ABBOTT, M.D.

Professor of Hygiene and Bacteriology, and Director of the Laboratory of Hygiene, University of Pennsylvania.

THE PRINCIPLES OF BACTERIOLOGY: A Practical Manual for Students and Physicians. Seventh Edition, with 100 Illustrations, 24 being coloured, post 8vo, 12s. 6d. *nett.*

R. W. ALLEN, M.D., B.S. LOND.,

Late Pathologist to the Royal Eye Hospital, London.

VACCINE THERAPY AND THE OPSONIC METHOD OF TREATMENT. Being the Second Edition of "The Opsonic Method of Treatment." Revised and enlarged, demy 8vo. [*In the press.*

H. CHARLTON BASTIAN, M.A., M.D., F.R.S.

Emeritus Professor of the Principles and Practice of Medicine in University College, London, etc.

I.

A TREATISE ON APHASIA AND OTHER SPEECH DEFECTS. With Illustrations, med. 8vo, 15s.

II.

PARALYSES: CEREBRAL, BULBAR, AND SPINAL. A Manual of Diagnosis for Students and Practitioners. With numerous Illustrations, 8vo, 12s. 6d.

III.

VARIOUS FORMS OF HYSTERICAL OR FUNCTIONAL PARALYSIS. Demy 8vo, 7s. 6d.

W. M. BEAUMONT.

Surgeon to the Bath Eye Infirmary.

INJURIES OF THE EYES OF THE EMPLOYED, and the Workmen's Compensation Act. Problems in Prognosis. Crown 8vo, 5s.

REGINALD R. BENNETT, B.SC. LOND., A.I.C.

Pharmaceutical Chemist, Pharmacist and Teacher of Pharmacy to University College Hospital, London, &c.

MATERIA MEDICA AND PHARMACY FOR MEDICAL STUDENTS. With an appendix on Incompatibility, fcap. 8vo, 4s. 6d. *nett.*

JOHN FAIRBAIRN BINNIE, A.M., C.M. ABERD.

Professor of Surgery, Kansas City Medical College, &c.

MANUAL OF OPERATIVE SURGERY. Third Edition, fully illustrated, post 8vo, bound leather, gilt edges, 12s. 6d. *nett.*

F. COLEMAN, L.R.C.P., M.R.C.S., L.D.S.

Assistant Dental Surgeon to St. Bartholomew's Hospital.

EXTRACTION OF TEETH. With 56 Illustrations, crown 8vo, 3s. *nett.* [*Just published.*

ARTHUR COOPER, M.R.C.S., L.R.C.P.

Consulting Surgeon to the Westminster General Dispensary, &c.

THE SEXUAL DISABILITIES OF MAN AND THEIR TREATMENT. With Illustrations, fcap. 8vo, 4s. *nett.* [*Just published.*

W. H. CORFIELD, M.A., M.D. OXON., F.R.C.P. LOND.

Late Professor of Hygiene and Public Health in University College, London.

I.

THE ETIOLOGY OF TYPHOID FEVER AND ITS PREVENTION, being the Milroy Lectures delivered at the Royal College of Physicians in 1902. Demy 8vo, 2s. 6d.

II.

DWELLING HOUSES: their Sanitary Construction and Arrangements. Fourth Edition, with Illustrations, crown 8vo. 3s. 6d.

III.

DISEASE AND DEFECTIVE HOUSE SANITATION. With Illustrations, crown 8vo, 2s.

SIDNEY COUPLAND, M.D., F.R.C.P.

Physician to the Middlesex Hospital, and Lecturer on Practical Medicine in the Medical School, etc.

NOTES ON THE CLINICAL EXAMINATION OF THE BLOOD AND EXCRETA. Third Edition, 12mo, 1s. 6d.

H. RADCLIFFE-CROCKER, M.D. LOND., B.S., F.R.C.P.

Physician for Diseases of the Skin in University College Hospital.

DISEASES OF THE SKIN: THEIR DESCRIPTION, PATHOLOGY, DIAGNOSIS, AND TREATMENT. Third Edition, with 76 Plates and 112 Illustrations, 2 vols., large 8vo, 30s. net.

J. SADLER CURGENVEN, M.R.C.S., L.R.C.P.

THE CHILD'S DIET. Crown 8vo, 1s. 6d. net.

J. MILNER FOTHERGILL, M.D.

I.

INDIGESTION AND BILIOUSNESS. Second Edition, post 8vo, 7s. 6d.

II.

GOUT IN ITS PROTEAN ASPECTS. Post 8vo, 7s. 6d.

III.

THE TOWN DWELLER: HIS NEEDS AND HIS WANTS. Post 8vo, 3s. 6d.

SIR DOUGLAS GALTON, K.C.B., HON. D.C.L., LL.D., F.R.S.

Formerly Secretary Railway Department Board of Trade; Assistant Inspector-General of Fortifications, &c.

HEALTHY HOSPITALS. OBSERVATIONS ON SOME POINTS CONNECTED WITH HOSPITAL CONSTRUCTION. With Illustrations, 8vo, 10s. 6d.

E. W. GOODALL, M.D. LOND.

Medical Superintendent of the Eastern Hospital of the Metropolitan Asylums Board; Formerly Medical Registrar to Guy's Hospital;

AND

J. W. WASHBOURN, C.M.G., M.D. LOND., F.R.C.P.

Physician to the London Fever Hospital; Assistant Physician to Guy's Hospital, and Lecturer in the Medical School.

A MANUAL OF INFECTIOUS DISEASES. Second Edition, revised and largely rewritten by E. W. GOODALL, Illustrated with Plates, Diagrams, and Charts, 8vo, 15s.

[*Nearly ready.*

JAMES F. GOODHART, M.D. ABERD., F.R.C.P.

Physician to Guy's Hospital, and Consulting Physician to the Evelina Hospital for Sick Children.

ON COMMON NEUROSES; OR THE NEUROTIC ELEMENT IN DISEASE AND ITS RATIONAL TREATMENT. Second Edition, crown 8vo, 3s. 6d.

GEORGE M. GOULD, A.M., M.D.

I.

THE PRACTITIONER'S MEDICAL DICTIONARY, an illustrated dictionary of Medicine and allied subjects, including all the words and phrases generally used in Medicine, with their proper pronunciation, derivation, and definition. Illustrated, medium 8vo, pp. xxvi. + 1043, thin paper, gilt edges, rounded corners, handsomely bound in limp leather, 21s. *nett.*

II.

THE STUDENT'S MEDICAL DICTIONARY: Including all the words and phrases generally used in Medicine, with their proper pronunciation and definitions. Eleventh Edition, with numerous Illustrations, 8vo, 14s. *nett.*

III.

A POCKET MEDICAL DICTIONARY, giving the Pronunciation and Definition of the Principal Words used in Medicine and the Collateral Sciences. Fourth edition, containing 30,000 words. Dose List revised in accordance with the U.S.A. Pharmacopœia, 1905. 32mo, 5s. net.

C. GRAHAM GRANT, L.R.C.P. AND S. EDIN.

Divisional Surgeon H. and Thames Divisions Metropolitan Police, Surgeon Poplar Hospital, &c.

POLICE-SURGEON'S EMERGENCY GUIDE. Fcap. 8vo, rounded corners, 2s.

DR. JOSEF GRUBER.

Professor of Otology in the University of Vienna, &c.

A TEXT-BOOK OF THE DISEASES OF THE EAR. Translated from the German, and Edited by EDWARD LAW, M.D., C.M. EDIN., M.R.C.S. ENG., Surgeon to the London Throat Hospital for Diseases of the Throat, Nose and Ear; and COLEMAN JEWELL, M.B. LOND., M.R.C.S. ENG. Second edition, with 165 Illustrations, and 70 coloured figures, royal 8vo, 28s.

O. C. GRUNER, M.B., LOND., M.R.C.S., L.R.C.P.

Clinical Pathologist to the General Infirmary, Leeds, &c.

STUDIES IN PUNCTURE FLUIDS. A contribution to Clinical Pathology. With 5 plates (2 coloured), and other Illustrations, demy 8vo, 7s. 6d. [*Just published.*

DRS. HARVEY AND DAVIDSON.

SYLLABUS OF MATERIA MEDICA. Revised in accordance with the "British Pharmacopœia" 1898, by WILLIAM MARTINDALE, F.L.S., F.C.S. Tenth edition, fcap. 16mo, 1s. *nett.*

BERKELEY HILL, M.B. LOND., F.R.C.S.

Professor of Clinical Surgery in University College,

AND

ARTHUR COOPER, M.R.C.S., L.R.C.P.

Consulting Surgeon to the Westminster General Dispensary, &c.

SYPHILIS AND LOCAL CONTAGIOUS DISORDERS. Second Edition, entirely re-written, royal 8vo, 18s.

E. LUCAS HUGHES, M.R.C.S. ENG., L.R.C.P. LOND.

Clinical Assistant, Ophthalmic Department, Royal Infirmary, Liverpool, &c.

SQUINT AND OCULAR PARALYSIS. With a short account of the Disturbances of Muscle Balance. With 53 Illustrations, demy 8vo, 6s. 6d. *nett.* [*Just published.*

SURGEON-MAJOR GEORGE A. HUTTON.

Late Rifle-Brigade (The Prince Consort's Own); Honorary Organising Commissioner, St. John Ambulance Association.

REMINISCENCES IN THE LIFE OF SURGEON-MAJOR GEORGE A. HUTTON. With an Introduction by R. LAWTON ROBERTS, M.D., J.P., Lecturer and Examiner of the St. John Ambulance Association. With Portrait, cr. 8vo, 5s. [*Now ready.*

EMILIA KANTHACK.

(MRS. DE VOSS.)

THE PRESERVATION OF INFANT LIFE. A guide for health visitors. With Preface by Dr. J. F. J. SYKES, Medical Officer of Health, St. Pancras. Crown 8vo, 1s. *nett.* [*Just published.*

J. WICKHAM LEGG, F.R.C.P.

Formerly Assistant Physician to Saint Bartholomew's Hospital.

A GUIDE TO THE EXAMINATION OF THE URINE. Seventh Edition, edited and revised by H. LEWIS JONES, M.D., Medical Officer in charge of the Electrical Department in St. Bartholomew's Hospital. With Illustrations, fcap. 8vo, 3s. 6d.

LEWIS'S PRACTICAL SERIES.

In Demy and Crown 8vo Volumes, with Illustrations.

CLINICAL BACTERIOLOGY AND HÆMATOLOGY FOR PRACTITIONERS. By W. D'ESTE EMERY, M.D., B.Sc. LOND., Clinical Pathologist to King's College Hospital, &c. Third Edition, 7s. 6d. *net.* [*Just published.*

DISEASES OF THE NERVOUS SYSTEM. A Handbook for Students and Practitioners. By C. E. BEEVOR, M.D. Lond., F.R.C.P., Physician to the National Hospital for the Paralysed and Epileptic. 10s. 6d.

THE TREATMENT OF PULMONARY CONSUMPTION. By VINCENT D. HARRIS, M.D. Lond., F.R.C.P., and E. CLIFFORD BEALE, M.A., M.B., Cantab., F.R.C.P., Physicians to the City of London Hospital for Diseases of the Chest, &c. 10s. 6d.

THE SURGICAL DISEASES OF CHILDREN AND THEIR TREATMENT BY MODERN METHODS. By D'ARCY POWER, F.R.C.S., Surgeon to St. Bartholomew's Hospital. 10s. 6d.

DISEASES OF THE NOSE & THROAT. By HERBERT TILLEY, M.D., B.S. Lond., F.R.C.S. Eng., Surgeon to the Ear and Throat Department, University College Hospital. Third Edition, 14s. *net.* [*Now ready.*

PUBLIC HEALTH LABORATORY WORK. By H. R. KENWOOD, M.B., D.P.H., F.C.S., Professor of Hygiene and Public Health, University College, &c. Fourth Edition, 10s. *net.* [*Just published.*

MEDICAL MICROSCOPY. By FRANK J. WETHERED, M.D., M.R.C.P., Medical Registrar to the Middlesex Hospital. 9s.

MEDICAL ELECTRICITY. By H. LEWIS JONES, M.A., M.D., F.R.C.P., Medical Officer, Electrical Department, St. Bartholomew's Hospital. Fifth Edition, thoroughly revised, demy 8vo, 12s. 6d. *net.*

HYGIENE AND PUBLIC HEALTH. By LOUIS PARKES, M.D., D.P.H. Lond. Univ., Lecturer on Public Health at St. George's Hospital, and H. R. KENWOOD, M.B., D.P.H., F.C.S., Professor of Hygiene and Public Health at University College, London. Third Edition, 10s. 6d. *net.*

MANUAL OF OPHTHALMIC PRACTICE, By C. HIGGENS, F.R.C.S., Lecturer on Ophthalmology at Guy's Hospital Medical School, &c. Second Edition, 7s. 6d.

A PRACTICAL TEXTBOOK OF THE DISEASES OF WOMEN. By ARTHUR H. N. LEWERS, M.D. Lond., F.R.C.P. Lond., Senior Obstetric Physician to the London Hospital. Sixth Edition, 10s. 6d.

ANÆSTHETICS: their Uses and Administration. By DUDLEY W. BUXTON, M.D., B.S., M.R.C.P., Administrator of Anæsthetics at University College Hospital, &c. Fourth Edition, 7s. 6d.

ON FEVERS: their History, Etiology, Diagnosis, Pro-gnosis and Treatment. By A. COLLIE, M.D. 8s. 6d.

THE OPERATIVE SURGERY OF THE EAR. By C. E. WEST, F.R.C.S., Assistant Aural Surgeon, St. Bartholomew's Hospital, and SYDNEY SCOTT, M.S., F.R.C.S., &c. With Illustrations, demy 8vo. [*In the press.*

A PRACTICAL TREATISE ON DISEASES OF THE KID-NEYS AND URINARY DERANGEMENTS. By C. H. RALFE, M.A., M.D. Cantab., F.R.C.P., Physician to the London Hospital. 10s. 6d.

DENTAL SURGERY FOR MEDICAL PRACTITIONERS AND STUDENTS OF MEDICINE. By ASHLEY W. BARRETT, M.B. Lond., M.R.C.S., L.D.S., Consulting Dental Surgeon to the London Hospital. Fourth Edition, 3s. 6d.

BODILY DEFORMITIES AND THEIR TREATMENT. By H. A. REEVES, F.R.C.S. Ed., Senior Assistant Surgeon and Teacher of Practical Surgery at the London Hospital. 8s. 6d.

ARTHUR H. N. LEWERS, M.D. LOND., F.R.C.P. LOND.

Senior Obstetric Physician to the London Hospital; late Examiner in Obstetric Medicine to the University of London.

CANCER OF THE UTERUS: A Clinical Monograph on its Diagnosis and Treatment. With 3 coloured Plates and numerous Illustrations, 8vo, 10s. 6d. *nett.*

WILLIAM A. M'KEOWN, M.D., M.CH.

Surgeon to the Ulster Eye, Ear and Throat Hospital, Belfast; Lecturer on Ophthalmology and Otology, Queen's College, Belfast.

A TREATISE ON "UNRIPE" CATARACT, and its Successful Treatment by Operation. With Illustrations, roy. 8vo, 12s. 6d. *nett.*

J. M. H. MACLEOD, M.A., M.D., M.R.C.P.

Assistant Physician for Diseases of the Skin, Charing Cross Hospital; Physician to the Skin Department, Victoria Hospital for Children; Lecturer on Skin Diseases, London School of Tropical Medicine.

PRACTICAL HANDBOOK OF THE PATHOLOGY OF THE SKIN. An Introduction to the Histology, Pathology, and Bacteriology of the Skin, with Special Reference to Technique. With 8 Coloured and 32 black and white Plates, demy 8vo, 15s. *nett.*

WILLIAM MARTINDALE, F.L.S., F.C.S.

Late President and Examiner of the Pharmaceutical Society,

AND

W. WYNN WESTCOTT, M.B. LOND., D.P.H.

H.M.'s Coroner for North-East London.

THE EXTRA PHARMACOPŒIA. Revised by W. H. MARTINDALE, PH.D., F.C.S., and W. WYNN WESTCOTT, M.B. LOND. &c. Thirteenth Edition, limp roan, med. 24mo, 10s. 6d. *nett.* [*Just published.*

A. STANFORD MORTON, M.B., F.R.C.S. ENG.

Surgeon to the Moorfields Ophthalmic Hospital; Ophthalmic Surgeon to the Great Northern Central Hospital, &c.

REFRACTION OF THE EYE; its Diagnosis and the Correction of its Errors. Seventh Edition, thoroughly revised, small 8vo, 3s. 6d.

DR. A. ONODI.

Lecturer on Rhino-Laryngology in the University of Budapest.

THE ANATOMY OF THE NASAL CAVITY, AND ITS ACCESSORY SINUSES. An Atlas for Practitioners and Students, translated by St. Clair Thomson, M.D. Lond. F.R.C.S. Eng., M.R.C.P. Lond. Plates, small 4to, 6s. *nett.*

WILLIAM OSLER, M.D., F.R.C.P. LOND.

Regius Professor of Medicine, University of Oxford.

ÆQUANIMITAS: With other Essays and Addresses to Medical Students, Nurses and Practitioners of Medicine. New Edition, with Three new Addresses. Post 8vo, 8s.

[*Now ready.*

KURRE W. OSTROM.

Instructor in Massage and Swedish Movements in the Philadelphia Polyclinic and College for Graduates in Medicine.

MASSAGE AND THE ORIGINAL SWEDISH MOVEMENTS; their application to various diseases of the body. Sixth Edition, with 115 illustrations, crown 8vo, 3s. 6d. *nett.*

SIR RICHARD DOUGLAS POWELL, BART., M.D. LOND., F.R.C.P.

Physician Extra-ordinary to H.M. the King; Physician to the Middlesex Hospital, &c.

I.

THE LUMLEIAN LECTURES ON THE PRINCIPLES WHICH GOVERN TREATMENT IN DISEASES AND DISORDERS OF THE HEART. Coloured Diagrams, demy 8vo, 6s.

II.

DISEASES OF THE LUNGS AND PLEURÆ INCLUDING CONSUMPTION. Fourth Edition, with coloured plates and wood-engravings, 8vo, 18s.

LOUIS BATHE RAWLING, M.B., B.C. CANTAB., F.R.C.S. ENG.

Assistant Surgeon, and Demonstrator of Practical and Operative Surgery, St. Bartholomew's Hospital; late Senior Demonstrator of Anatomy and Assistant Surgeon to the German Hospital, Dalston.

LANDMARKS AND SURFACE MARKINGS OF THE HUMAN BODY. Third Edition, demy 8vo, 29 plates (3 in colour), 5s. *nett.* [*Just published.*

SAMUEL RIDEAL, D.SC. LOND., F.I.C., F.C.S.

Fellow of University College, London.

I.

PRACTICAL ORGANIC CHEMISTRY. The detection and properties of some of the more important Organic Compounds. Second Edition, 12mo, 2s. 6d.

II.

PRACTICAL CHEMISTRY FOR MEDICAL STUDENTS, Required at the First Examination of the Conjoint Examining Board in England. Fcap. 8vo, 2s.

J. JAMES RIDGE, M.D., B.S., B.A., B.SC. LOND.

Late Medical Officer of Health, Enfield.

ALCOHOL AND PUBLIC HEALTH. Second Edition, crown 8vo, 2s.

FREDERICK T. ROBERTS, M.D., B.SC., F.R.C.P.

Emeritus Professor of Medicine and Clinical Medicine in University College, Consulting Physician to University College Hospital, &c.

THE THEORY AND PRACTICE OF MEDICINE. Tenth Edition, 2 vols., with Illustrations, lge. 8vo, 26s. *nett.*

WILLIAM ROSE, B.S., M.B. LOND., F.R.C.S.

Professor of Surgery in King's College, London, and Surgeon to King's College Hospital, &c.

ON HARELIP AND CLEFT PALATE. Demy 8vo, with Illustrations, 6s.

BERNARD ROTH, F.R.C.S.

Orthopædic Surgeon to the Royal Alexandra Hospital for Sick Children, &c.

THE TREATMENT OF LATERAL CURVATURE OF THE SPINE. Second Edition, with Photographic and other Illustrations, roy. 8vo, 10s. 6d.

W. G. SAVAGE, B.SC., M.D. LOND., D.P.H.

Medical Officer of Health and Public Analyst, Colchester; late Lecturer on Bacteriology and Public Health, University College, Cardiff, &c.

THE BACTERIOLOGICAL EXAMINATION OF WATER-SUPPLIES. With Tables and Illustrations, post 8vo, 6s. 6d. *nett.*

G. E. SHUTTLEWORTH, B.A., M.D.

Recently Medical Examiner of Defective Children, School Board for London; late Medical Superintendent, Royal Albert Asylum for Idiots and Imbeciles of the Northern Counties, Lancaster, &c.

MENTALLY-DEFICIENT CHILDREN: their Treatment and Training. Second Edition, with Illustrations, crown 8vo, 5s. *nett.*

E. HUGH SNELL, M.D., B.SC. LOND.

Diplomate in Public Health of the University of Cambridge; Medical Officer of Health, Coventry; late London County Council Medical Officer to the Blackwall Tunnel.

COMPRESSED AIR ILLNESS, OR SO-CALLED CAISSON DISEASE. Demy 8vo, 10s. 6d.

LOUIS STARR, M.D.

Physician to the Children's Hospital, Philadelphia, &c.

HYGIENE OF THE NURSERY. Including the General Regimen and Feeding of Infants and Children; Massage, and the Domestic Management of the Ordinary Emergencies of Early Life. Seventh Edition, with Illustrations, cr. 8vo, 3s. 6d.

W. H. B. STODDART, M.D., LOND.

Assistant Medical Officer, Bethlem and Bridewell Royal Hospitals, &c.

THE MIND AND ITS DISORDERS. With Plates and other Illustrations, demy 8vo. [*In the press.*

J. BLAND-SUTTON, F.R.C.S.

Assistant Surgeon to the Middlesex Hospital.

LIGAMENTS: THEIR NATURE AND MORPHOLOGY. Third Edition, wood engravings, post 8vo, 4s. 6d.

ALBERT TAYLOR.

Member Royal Sanitary Institute; Sanitary Inspector, City of Westminster; late Chief Sanitary Inspector to the Vestry of St. George, Hanover Square, etc.

THE SANITARY INSPECTOR'S HANDBOOK. Fourth Edition, with Illustrations, cr. 8vo, 6s.

E. W. AINLEY WALKER, M.A., D.M. OXON.,

Fellow and Praelector of University College, Oxford; late Gordon Lecturer in Experimental Pathology at Guy's Hospital, &c.

THE GENERAL PATHOLOGY OF INFLAMMATION, INFECTION, AND FEVER. Being the Gordon Lectures for 1902, crown 8vo, 4s. 6d. net.

HUGH WALSHAM, M.A., M.D. CANTAB.

Fellow of the Royal College of Physicians; Chief Assistant in the Electrical Department of St. Bartholomew's Hospital; Senior Assistant Physician to the City of London Hospital for Diseases of the Chest.

AND

GEORGE HARRISON ORTON, M.A., M.D. CANTAB.

Assistant in the Röntgen Ray Department of St. Bartholomew's Hospital; Medical Officer in charge of the X-Ray Department of the National Hospital for Diseases of the Heart, and the Cheyne Hospital for Sick Children.

THE X-RAYS IN THE DIAGNOSIS OF DISEASES OF THE CHEST. With 18 specially prepared plates from selected negatives, and other illustrations, demy 8vo, 6s. net.

R. PROSSER WHITE, M.D. EDIN., M.R.C.S. ENG.

Life Vice-President and Honorary Medical Officer, Royal Albert Edward Infirmary, Wigan.

CATARRHAL FEVERS, COMMONLY CALLED COLDS: their Causes, Consequences, Control, and Cure. With 3 plates, extra demy 8vo, 4s. [*Now ready*.

E. T. WILSON, M.B. OXON., F.R.C.P. LOND.

Physician to the Cheltenham General Hospital, &c.

DISINFECTANTS AND ANTISEPTICS: HOW TO USE THEM. In Packets of one doz. price 1s., by post 1s. 1d. [*Thoroughly revised*.

BERTRAM C. A. WINDLE, D.SC., M.D., M.A. DUBL.

President, Queen's College, Cork; Examiner in Anatomy, Royal College of Physicians, London, &c.

A HANDBOOK OF SURFACE ANATOMY AND LANDMARKS. Third Edition, with Illustrations, post 8vo, 4s. *nett*.

EDWARD WOAKES, M.D. LOND.

Senior Aural Surgeon, London Hospital; Lecturer on Diseases of the Ear, London Hospital Medical College.

ON DEAFNESS, GIDDINESS, AND NOISES IN THE HEAD. Fourth Edition, Part I., with Illustrations, 8vo, 10s. 6d.

All Charts sent post free. Specimen of any Chart free.

LEWIS'S DIET CHARTS. A Suggestive set of Diet Tables for the use of Physicians, for handing to Patients after Consultation, modified to suit Individual Requirements; for Albuminuria, Anæmia and Debility, Constipation, Diabetes, Diarrhœa, Dyspepsia, Eczema, Fevers, Gall Stones, Gout and Gravel, Heart Disease (chronic), Nervous Diseases, Obesity, Phthisis, Rheumatism (chronic); and Blank Chart for other diseases. 5s. per packet of 100 charts, post free.

A special leaflet on the Diet and Management of Infants is sold separately. 12, 1s.; 100, 7s. 6d., post free.

CHART FOR RECORDING THE EXAMINATION OF URINE. Designed for the use of medical men, analysts and others making examinations of the urine of patients. 10, 1s.; 100, 7s. 6d.; 250, 15s.; 500, 25s.; 1000, 40s.

CLINICAL CHARTS FOR TEMPERATURE OBSERVATIONS, ETC. Arranged by W. RIGDEN, M.R.C.S. 12, 1s.; 100, 7s.; 250, 15s.; 500, 28s.; 1000, 50s.

LEWIS'S HÆMATOLOGICAL CHART. A new Chart designed for recording Counts, &c., designed by Dr. E. R. TURTON. 1000, 50s.; 500, 28s.; 250, 15s.; 100, 7s.; 12, 1s.

LEWIS'S CLINICAL CHART, SPECIALLY DESIGNED FOR USE WITH THE VISITING LIST. Arranged for four weeks, and measures 6 × 3 inches. 12, 6d.; 25, 1s.; 100, 2s. 6d.; 500, 11s. 6d.; 1000, 20s.

LEWIS'S "HANDY" TEMPERATURE CHART. Arranged for three weeks, with space for notes of case as to diet, &c., and ruled on back for recording observations on urine. 20, 1s.; 50, 2s.; 100, 3s. 6d.; 500, 14s.; 1000, 25s.

Uniform in size and price with the "Handy" Chart :—

LEWIS'S FOUR-HOUR TEMPERATURE CHART. Meets the requirements of a chart on which the temperature and other observations can be recorded at intervals of four hours. Each chart will last a week.

LEWIS'S NURSING CHART. Printed on both sides.

LEWIS'S BLOOD-PRESSURE AND PULSE CHART. An entirely new Chart.

LEWIS'S SMALL FOUR-HOUR TEMPERATURE CHART. Designed by G. C. COLES, M.R.C.S. Each chart lasts two weeks and gives space for noting Pulse, Respiration and Urine, and Remarks.

LEWIS'S MORNING AND EVENING TEMPERATURE CHART. Designed by G. C. COLES, M.R.C.S. Each chart lasts three weeks, and provides space for noting also the Pulse, Respiration, and Urine, and general Remarks.

LEWIS'S
PRACTICAL
SERIES